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Chen et al.

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(45) **Date of Patent:** **Mar. 11, 2025**

(54) **OPTICAL IMAGING LENS**

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(73) Assignee: **Genius Electronic Optical (Xiamen) Co., Ltd.**, Xiamen (CN)

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(22) Filed: **Apr. 12, 2022**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Dec. 8, 2021 (CN) 202111490150.1

(51) **Int. Cl.**
G02B 9/64 (2006.01)
G02B 13/00 (2006.01)
G02B 3/00 (2006.01)

(52) **U.S. Cl.**
CPC **G02B 9/64** (2013.01); **G02B 13/0045** (2013.01); **G02B 2003/0093** (2013.01)

(58) **Field of Classification Search**

CPC G02B 3/64
See application file for complete search history.

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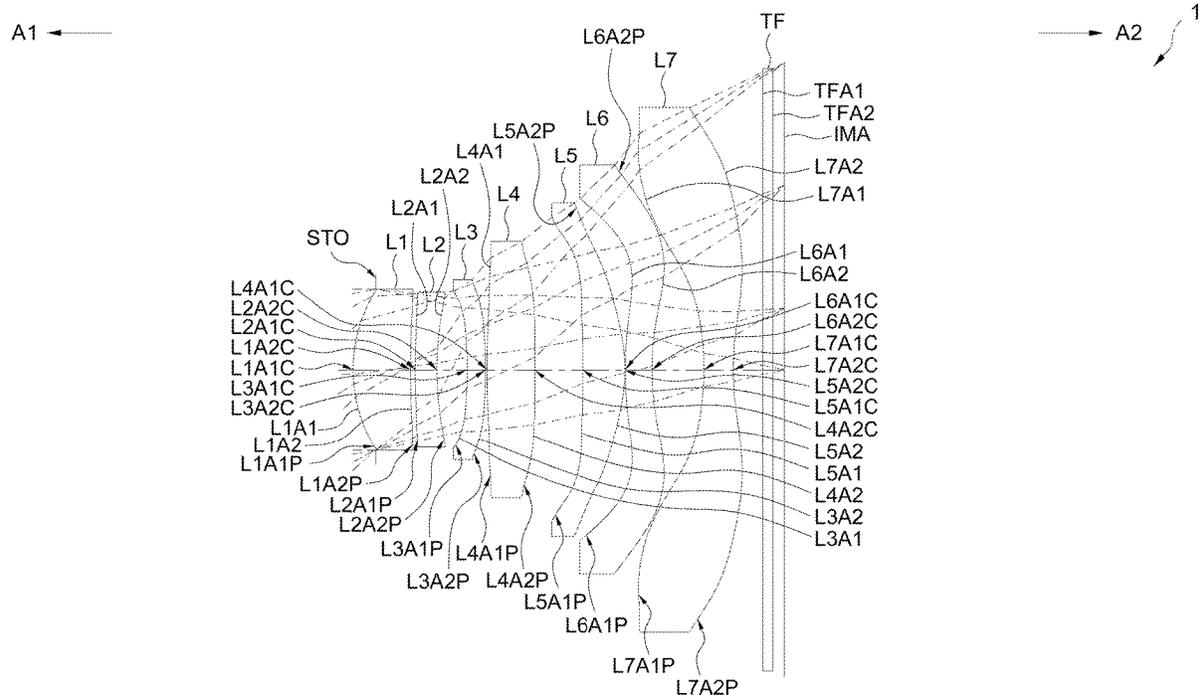
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(57) **ABSTRACT**

An optical imaging lens may include a first lens element, a second lens element, a third lens element, a fourth lens element, a fifth lens element, a sixth lens element and a seventh lens element positioned in an order from an object side to an image side. Through designing concave and/or convex surfaces of the lens elements, the optical imaging lens may provide slim and compact appearance, small fno and great image height along with well image quality.

20 Claims, 44 Drawing Sheets



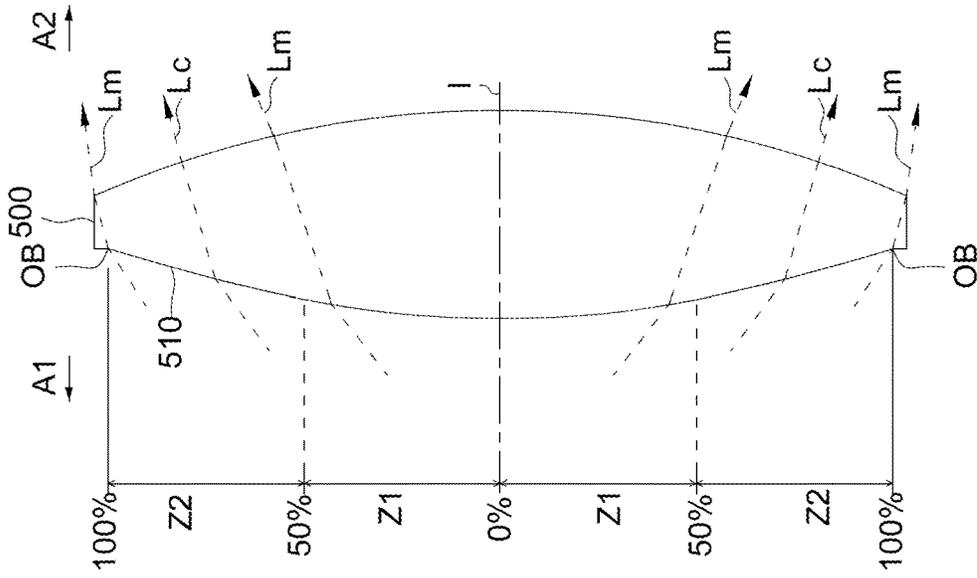


FIG. 5

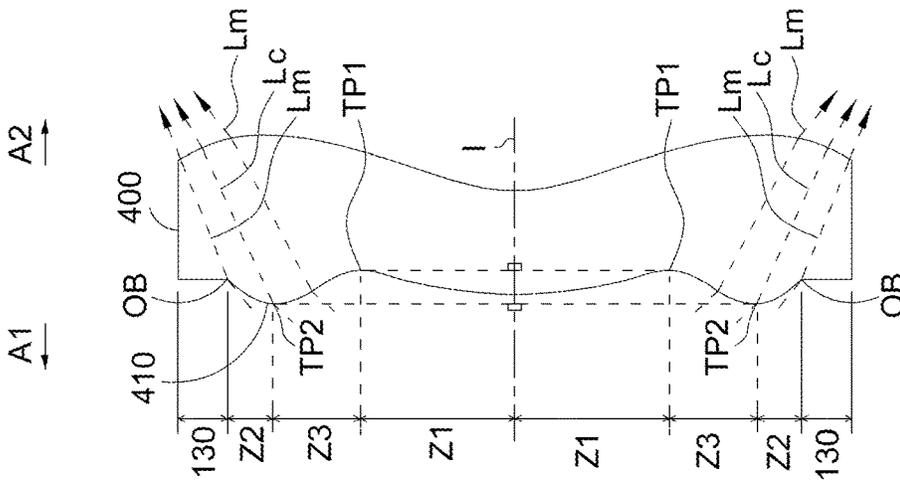


FIG. 4

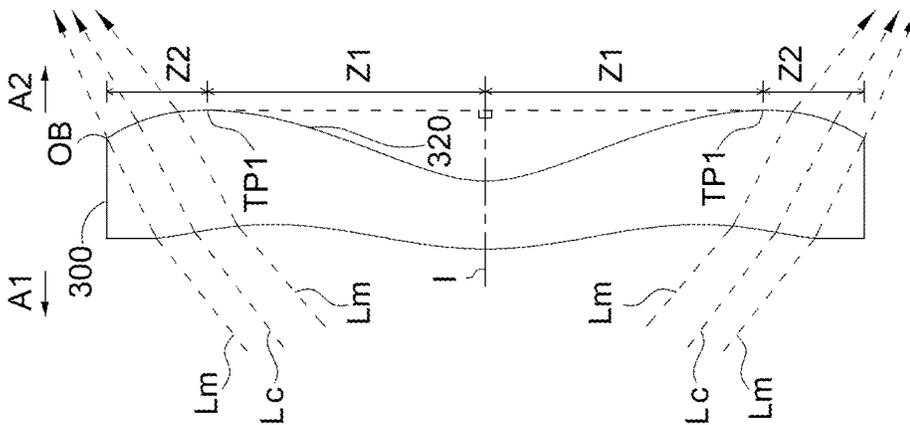


FIG. 3

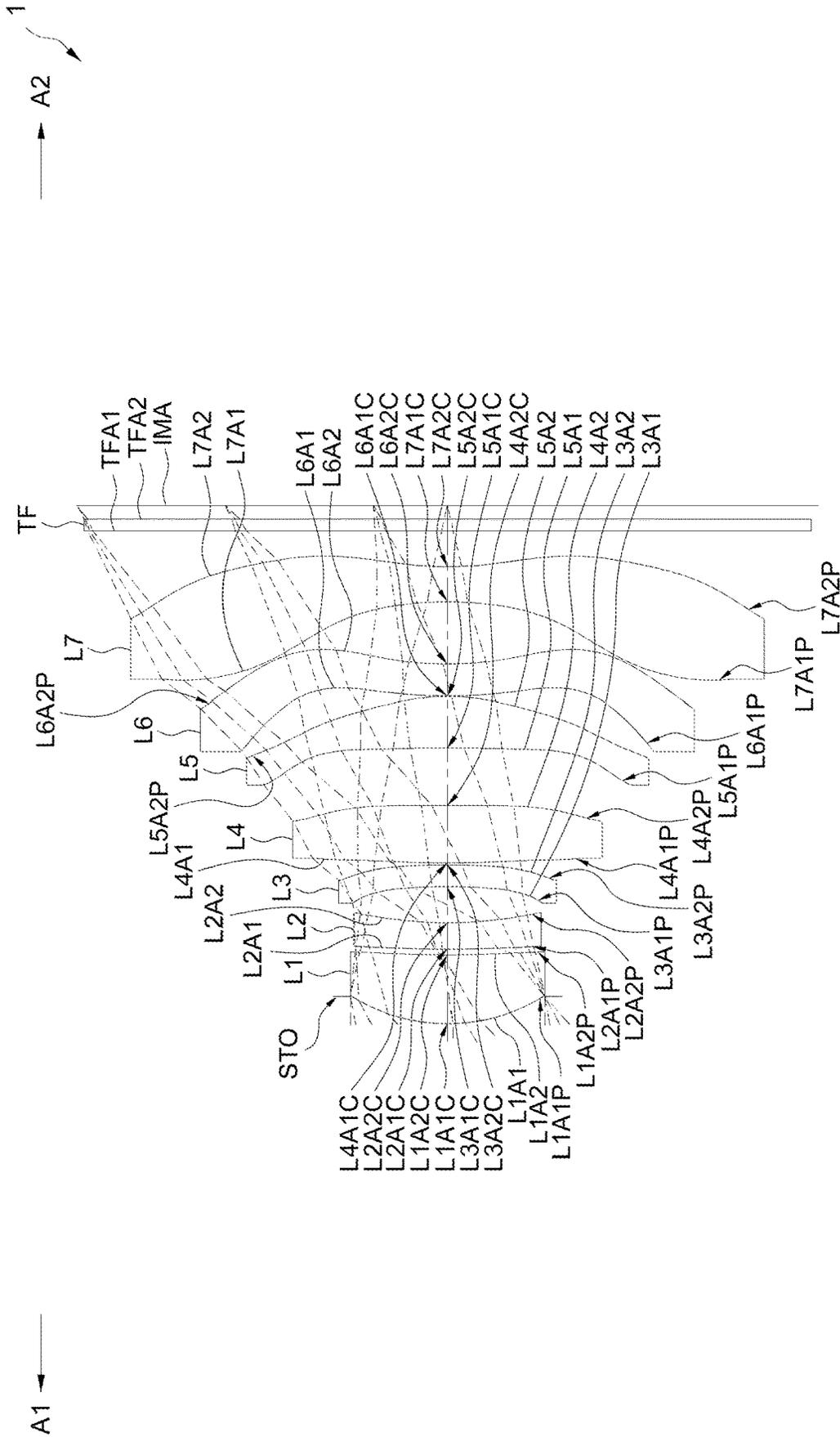


FIG. 6

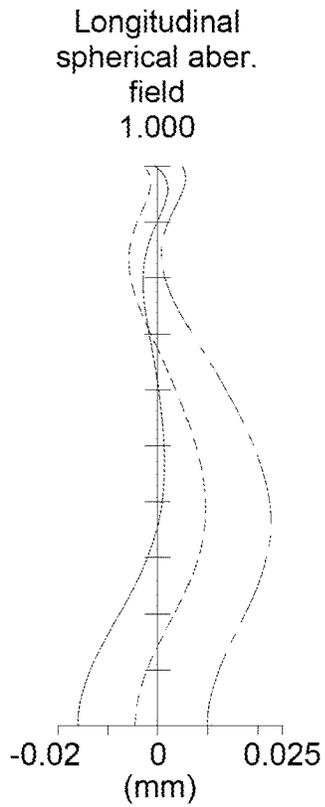


FIG. 7A

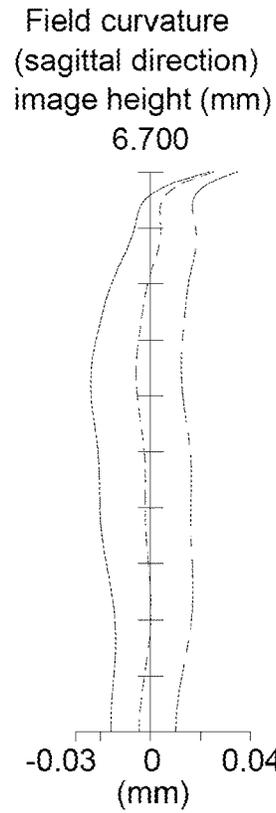


FIG. 7B

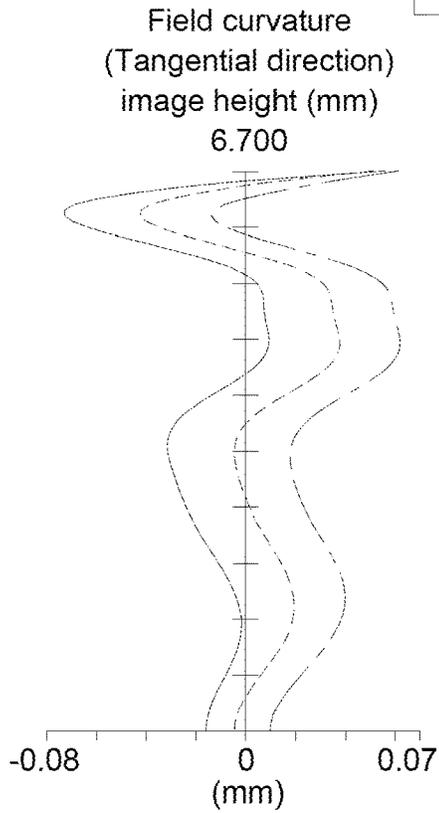
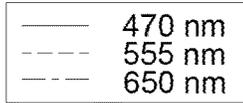


FIG. 7C

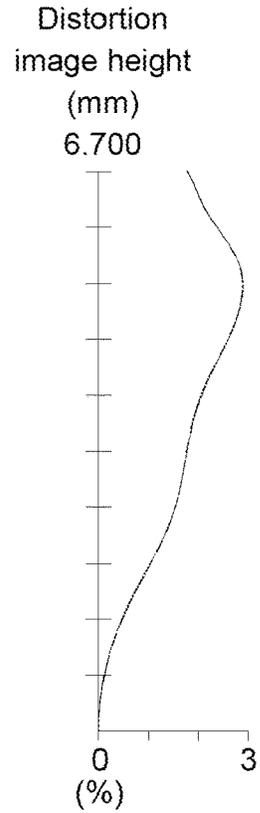


FIG. 7D

Embodiment 1							
EFL = 7.370 mm ; HFOV = 41.746 degrees ; TTL = 9.376 mm							
Fno = 2.100 ; Image Height = 6.700 mm							
Surface #		Radius of curvature (mm)	Thickness /air gap (mm)	Refractive index	Abbe number	Focal length (mm)	Material
OBJ	Object	INFINITY	INFINITY				
STO	Aperture stop	INFINITY	-0.495				
L1A1	1st lens element	3.279	1.242	1.545	55.987	7.590	Plastic
L1A2		13.581	0.106				
L2A1	2nd lens element	14.989	0.473	1.661	20.373	-21.690	Plastic
L2A2		7.269	0.655				
L3A1	3rd lens element	-11.399	0.394	1.661	20.373	-44.369	Plastic
L3A2		-18.795	0.032				
L4A1	4th lens element	10.106	1.045	1.545	55.987	20.394	Plastic
L4A2		104.821	1.041				
L5A1	5th lens element	-69.433	0.929	1.545	55.987	7.112	Plastic
L5A2		-3.697	0.013				
L6A1	6th lens element	12.429	0.576	1.661	20.373	-26.894	Plastic
L6A2		7.206	1.124				
L7A1	7th lens element	-6.167	0.637	1.545	55.987	-5.326	Plastic
L7A2		5.709	0.650				
TFA1	Filtering unit	INFINITY	0.210	1.517	64.167		
TFA2		INFINITY	0.249				
IMA	Image plane	INFINITY					

FIG. 8

Embodiment 1					
Aspherical Parameters					
Surface#	K	a4	a6	a8	a10
L1A1	3.349382E-02	-5.721388E-04	1.441325E-03	-1.280507E-03	6.294266E-04
L1A2	0.000000E+00	-1.115169E-02	8.452667E-04	1.197739E-03	-5.137937E-04
L2A1	0.000000E+00	-1.203976E-02	-1.620757E-03	5.686367E-03	-3.290319E-03
L2A2	7.599856E-01	-2.780083E-03	-1.680844E-03	3.711251E-03	-2.427587E-03
L3A1	0.000000E+00	-3.235598E-03	-8.478566E-03	3.812224E-03	-1.923699E-03
L3A2	0.000000E+00	-1.725610E-02	2.323855E-03	1.501744E-03	-2.092860E-03
L4A1	9.849770E-02	-2.755491E-02	1.362792E-02	-4.898558E-03	1.075023E-03
L4A2	0.000000E+00	-8.119346E-03	-6.544655E-04	8.636470E-04	-4.327605E-04
L5A1	0.000000E+00	-8.429429E-03	5.989403E-03	-1.794603E-03	1.545223E-04
L5A2	-6.456111E-01	1.347204E-02	8.102424E-04	-8.902212E-04	1.806221E-04
L6A1	0.000000E+00	1.758286E-02	-7.491496E-03	6.336561E-04	8.606026E-05
L6A2	0.000000E+00	1.636689E-02	-9.000213E-03	1.617549E-03	-1.718289E-04
L7A1	3.812064E-03	7.771944E-03	-5.733587E-03	1.107978E-03	-1.051685E-04
L7A2	-8.308480E+00	-4.271133E-03	-1.301119E-03	2.725594E-04	-2.505540E-05
Surface#	a12	a14	a16	a18	a20
L1A1	-1.747028E-04	2.482302E-05	-1.442715E-06	/	/
L1A2	8.797387E-05	-6.424030E-06	1.837160E-07		
L2A1	1.033000E-03	-1.759804E-04	1.303272E-05		
L2A2	8.064669E-04	-1.391908E-04	8.330739E-06		
L3A1	4.441908E-04	-4.275378E-05	4.930121E-07		
L3A2	8.009253E-04	-1.354728E-04	9.753450E-06		
L4A1	-1.324057E-04	8.612163E-06	-2.447684E-07		
L4A2	1.359908E-04	-2.769390E-05	3.464553E-06	-2.346820E-07	6.492117E-09
L5A1	2.584955E-05	-8.219208E-06	8.989566E-07	-4.573283E-08	9.006590E-10
L5A2	-2.324861E-05	2.377765E-06	-1.706624E-07	6.902144E-09	-1.147520E-10
L6A1	-2.757504E-05	2.942970E-06	-1.495521E-07	3.245906E-09	-1.408200E-11
L6A2	1.099499E-05	-3.863583E-07	5.145569E-09	6.398500E-11	-1.905000E-12
L7A1	5.896381E-06	-2.055389E-07	4.399296E-09	-5.315700E-11	2.790000E-13
L7A2	1.380153E-06	-4.868906E-08	1.077392E-09	-1.355200E-11	7.400000E-14

FIG. 9

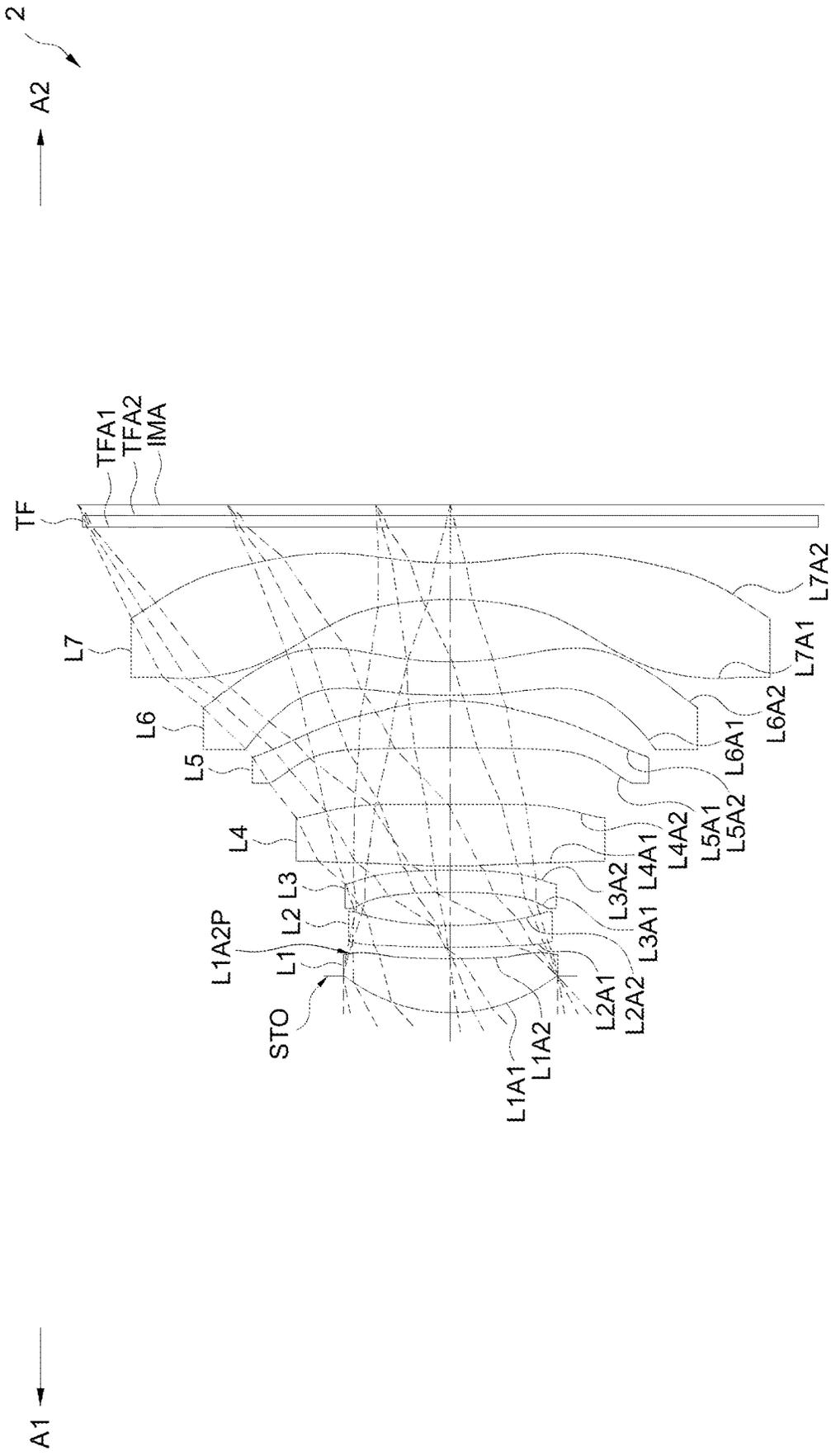


FIG. 10

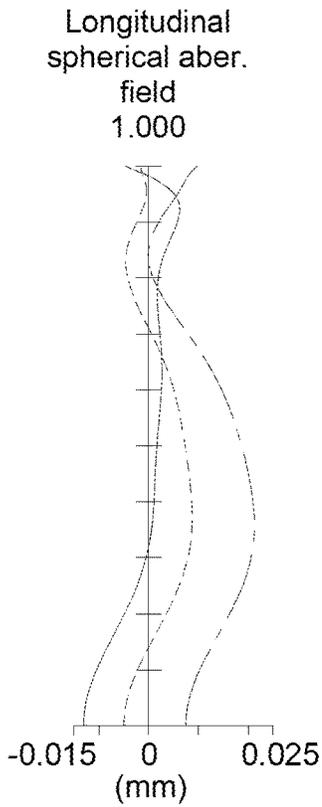


FIG. 11A

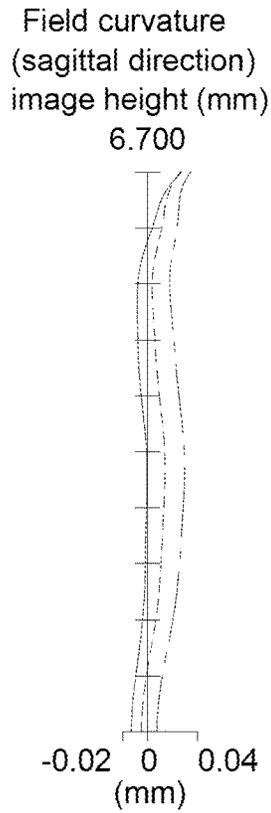


FIG. 11B

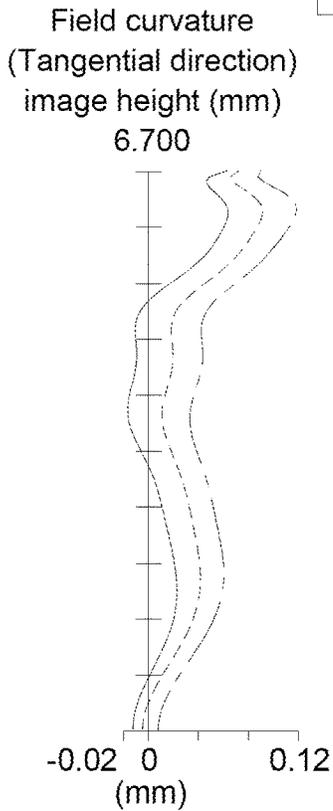
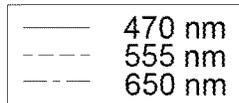


FIG. 11C

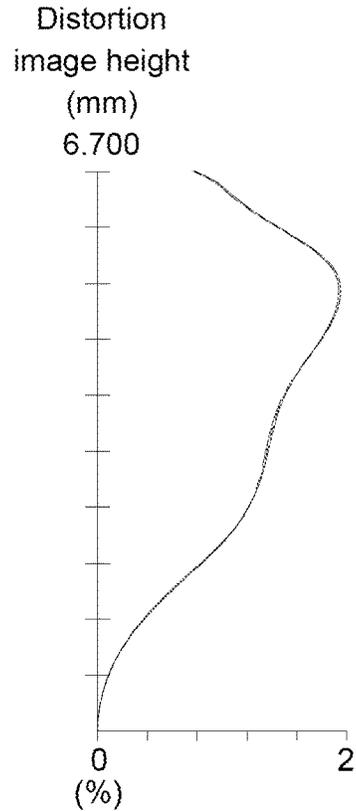


FIG. 11D

Embodiment 2							
EFL = 7.286 mm ; HFOV = 42.346 degrees ; TTL = 9.146 mm							
Fno = 1.891 ; Image Height = 6.700 mm							
Surface #		Radius of curvature (mm)	Thickness /air gap (mm)	Refractive index	Abbe number	Focal length (mm)	Material
OBJ	Object	INFINITY	INFINITY				
STO	Aperture stop	INFINITY	-0.654				
L1A1	1st lens element	3.084	0.966	1.545	55.987	7.304	Plastic
L1A2		12.084	0.210				
L2A1	2nd lens element	15.185	0.388	1.661	20.373	-19.305	Plastic
L2A2		6.897	0.597				
L3A1	3rd lens element	-11.844	0.396	1.661	20.373	-54.582	Plastic
L3A2		-17.789	0.079				
L4A1	4th lens element	9.788	1.113	1.545	55.987	21.333	Plastic
L4A2		58.666	1.017				
L5A1	5th lens element	-121.450	0.840	1.545	55.987	7.441	Plastic
L5A2		-3.943	0.102				
L6A1	6th lens element	13.993	0.603	1.661	20.373	-24.777	Plastic
L6A2		7.447	1.124				
L7A1	7th lens element	-6.170	0.657	1.545	55.987	-5.477	Plastic
L7A2		6.027	0.650				
TFA1	Filtering unit	INFINITY	0.210	1.517	64.167		
TFA2		INFINITY	0.196				
IMA	Image plane	INFINITY					

FIG. 12

Embodiment 2					
Aspherical Parameters					
Surface#	K	a4	a6	a8	a10
L1A1	2.277005E-02	-2.918487E-04	1.526327E-03	-1.303495E-03	6.195129E-04
L1A2	0.000000E+00	-6.399889E-03	-2.519398E-04	9.505689E-04	-4.685269E-04
L2A1	0.000000E+00	-8.494326E-03	-1.963475E-03	5.525242E-03	-3.279215E-03
L2A2	1.416126E+00	-2.322277E-03	-5.462976E-04	3.668855E-03	-2.429320E-03
L3A1	0.000000E+00	-3.282433E-03	-7.626657E-03	4.000615E-03	-1.945882E-03
L3A2	0.000000E+00	-1.809413E-02	2.989247E-03	1.514951E-03	-2.085520E-03
L4A1	6.013783E-01	-2.777491E-02	1.362691E-02	-4.908823E-03	1.072735E-03
L4A2	0.000000E+00	-7.734658E-03	-7.132203E-04	8.634602E-04	-4.314380E-04
L5A1	0.000000E+00	-8.417187E-03	5.967869E-03	-1.795937E-03	1.544705E-04
L5A2	-6.279514E-01	1.340620E-02	7.920873E-04	-8.903203E-04	1.805907E-04
L6A1	0.000000E+00	1.778131E-02	-7.451241E-03	6.332624E-04	8.597300E-05
L6A2	0.000000E+00	1.647448E-02	-8.996983E-03	1.617555E-03	-1.718337E-04
L7A1	1.617419E-03	7.762821E-03	-5.733743E-03	1.107978E-03	-1.051684E-04
L7A2	-9.524308E+00	-4.173777E-03	-1.300715E-03	2.725438E-04	-2.505575E-05
Surface#	a12	a14	a16	a18	a20
L1A1	-1.724929E-04	2.546304E-05	-1.889755E-06	\	\
L1A2	1.028914E-04	-1.179787E-05	5.294001E-07		
L2A1	1.044740E-03	-1.742029E-04	1.268612E-05		
L2A2	8.004029E-04	-1.333078E-04	8.658765E-06		
L3A1	4.183395E-04	-4.612148E-05	3.767139E-06		
L3A2	7.860690E-04	-1.366832E-04	1.091651E-05		
L4A1	-1.313422E-04	8.653252E-06	-2.612590E-07	-2.349563E-07	6.559043E-09
L4A2	1.360970E-04	-2.770177E-05	3.460002E-06	-4.573083E-08	9.006100E-10
L5A1	2.585431E-05	-8.218611E-06	8.989936E-07	6.902327E-09	-1.146060E-10
L5A2	-2.325209E-05	2.377597E-06	-1.706573E-07	3.245220E-09	-1.416100E-11
L6A1	-2.757676E-05	2.942875E-06	-1.495407E-07	6.397600E-11	-1.904000E-12
L6A2	1.099478E-05	-3.863662E-07	5.145509E-09	-5.315700E-11	2.790000E-13
L7A1	5.896371E-06	-2.055389E-07	4.399294E-09	-1.355300E-11	7.400000E-14
L7A2	1.380147E-06	-4.868921E-08	1.077388E-09		

FIG. 13

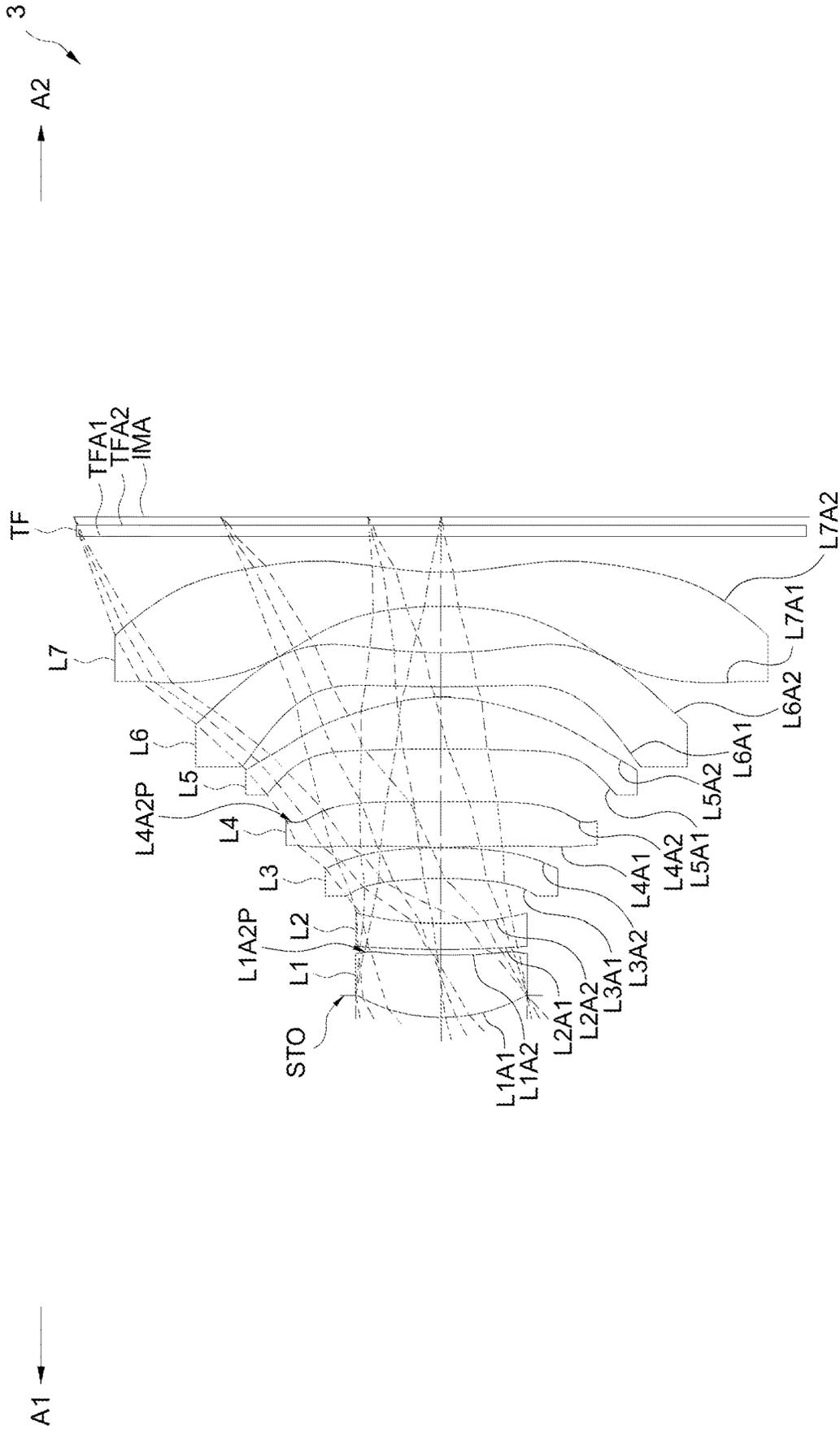


FIG. 14

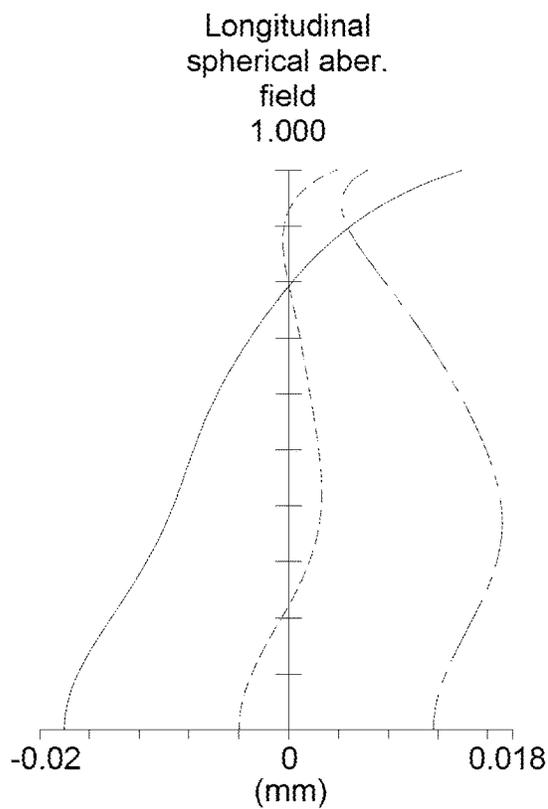


FIG. 15A

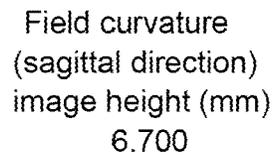


FIG. 15B

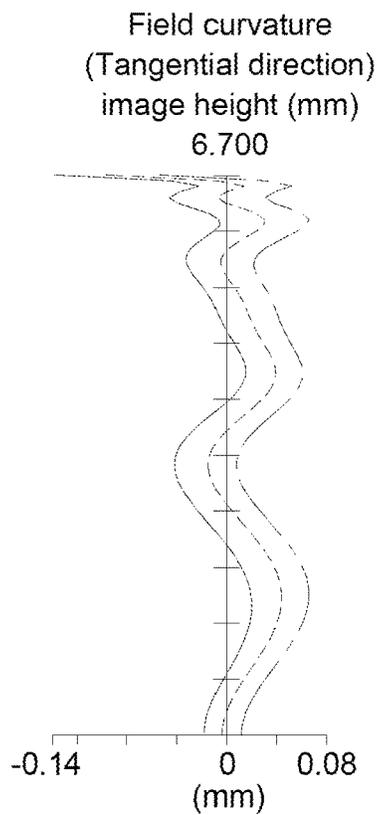
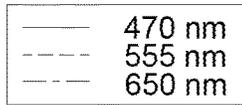


FIG. 15C

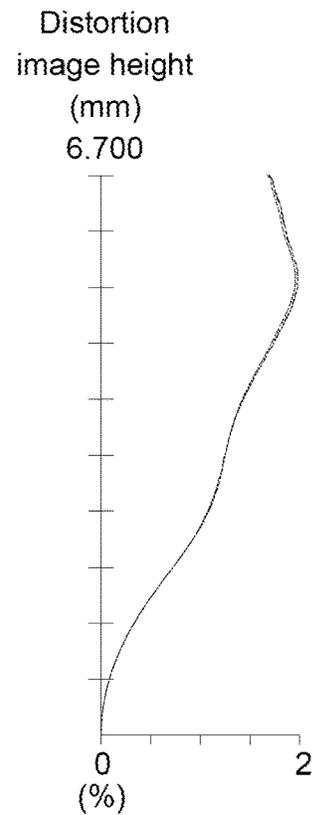


FIG. 15D

Embodiment 3							
EFL = 7.175 mm ; HFOV = 42.068 degrees ; TTL = 9.136 mm							
Fno = 2.300 ; Image Height = 6.700 mm							
Surface #		Radius of curvature (mm)	Thickness /air gap (mm)	Refractive index	Abbe number	Focal length (mm)	Material
OBJ	Object	INFINITY	INFINITY				
STO	Aperture stop	INFINITY	-0.399				
L1A1	1st lens element	3.124	1.138	1.545	55.987	6.913	Plastic
L1A2		15.745	0.105				
L2A1	2nd lens element	16.488	0.477	1.661	20.373	-22.816	Plastic
L2A2		7.823	0.812				
L3A1	3rd lens element	-9.225	0.559	1.661	20.373	-57.792	Plastic
L3A2		-12.420	0.013				
L4A1	4th lens element	13.230	0.831	1.545	55.987	31.031	Plastic
L4A2		58.929	0.962				
L5A1	5th lens element	-114.738	0.949	1.545	55.987	6.610	Plastic
L5A2		-3.511	0.184				
L6A1	6th lens element	53.567	0.621	1.661	20.373	-19.728	Plastic
L6A2		10.516	0.850				
L7A1	7th lens element	-6.210	0.621	1.545	55.987	-5.288	Plastic
L7A2		5.591	0.650				
TFA1	Filtering unit	INFINITY	0.210	1.517	64.167		
TFA2		INFINITY	0.153				
IMA	Image plane	INFINITY					

FIG. 16

Embodiment 3					
Aspherical Parameters					
Surface#	K	a4	a6	a8	a10
L1A1	2.104435E-01	-1.162923E-03	1.044954E-03	-1.228669E-03	6.056831E-04
L1A2	0.000000E+00	-8.465441E-03	-4.049954E-04	9.539425E-04	-4.996496E-04
L2A1	0.000000E+00	-5.343584E-03	-3.195082E-03	5.512255E-03	-3.232868E-03
L2A2	7.230623E+00	1.369859E-03	-2.485148E-03	3.936445E-03	-2.402121E-03
L3A1	0.000000E+00	-2.626314E-03	-7.840451E-03	3.990987E-03	-1.934825E-03
L3A2	0.000000E+00	-1.565490E-02	3.230734E-03	1.565289E-03	-2.105455E-03
L4A1	1.606093E+00	-2.760631E-02	1.357432E-02	-4.904479E-03	1.073968E-03
L4A2	0.000000E+00	-9.047139E-03	-8.592486E-04	8.541081E-04	-4.316790E-04
L5A1	0.000000E+00	-8.170112E-03	5.837144E-03	-1.796446E-03	1.540229E-04
L5A2	-5.873648E-01	1.272956E-02	8.038156E-04	-8.887215E-04	1.806722E-04
L6A1	0.000000E+00	1.514101E-02	-7.406064E-03	6.364140E-04	8.604470E-05
L6A2	0.000000E+00	1.622464E-02	-8.996455E-03	1.618000E-03	-1.718052E-04
L7A1	3.221968E-02	7.880416E-03	-5.734399E-03	1.107920E-03	-1.051701E-04
L7A2	-9.156885E+00	-3.927753E-03	-1.306359E-03	2.724874E-04	-2.505591E-05
Surface#	a12	a14	a16	a18	a20
L1A1	-1.786389E-04	2.531474E-05	-1.743090E-06	\	\
L1A2	1.013165E-04	-1.191309E-05	2.066525E-06		
L2A1	1.046215E-03	-1.780566E-04	1.458673E-05		
L2A2	7.917798E-04	-1.341995E-04	9.691054E-06		
L3A1	4.419906E-04	-3.621652E-05	-3.679292E-06		
L3A2	7.955728E-04	-1.356916E-04	9.111798E-06		
L4A1	-1.323289E-04	8.645626E-06	-2.361086E-07	-2.349069E-07	6.505810E-09
L4A2	1.362234E-04	-2.767756E-05	3.464397E-06	-4.570037E-08	9.032010E-10
L5A1	2.579347E-05	-8.223877E-06	8.989245E-07	6.901459E-09	-1.150950E-10
L5A2	-2.324058E-05	2.378083E-06	-1.706765E-07	3.248486E-09	-1.376200E-11
L6A1	-2.758769E-05	2.942227E-06	-1.495163E-07	6.394900E-11	-1.909000E-12
L6A2	1.099537E-05	-3.863431E-07	5.144719E-09	-5.315600E-11	2.790000E-13
L7A1	5.896343E-06	-2.055395E-07	4.399308E-09	-1.355300E-11	7.400000E-14
L7A2	1.380154E-06	-4.868907E-08	1.077390E-09		

FIG. 17

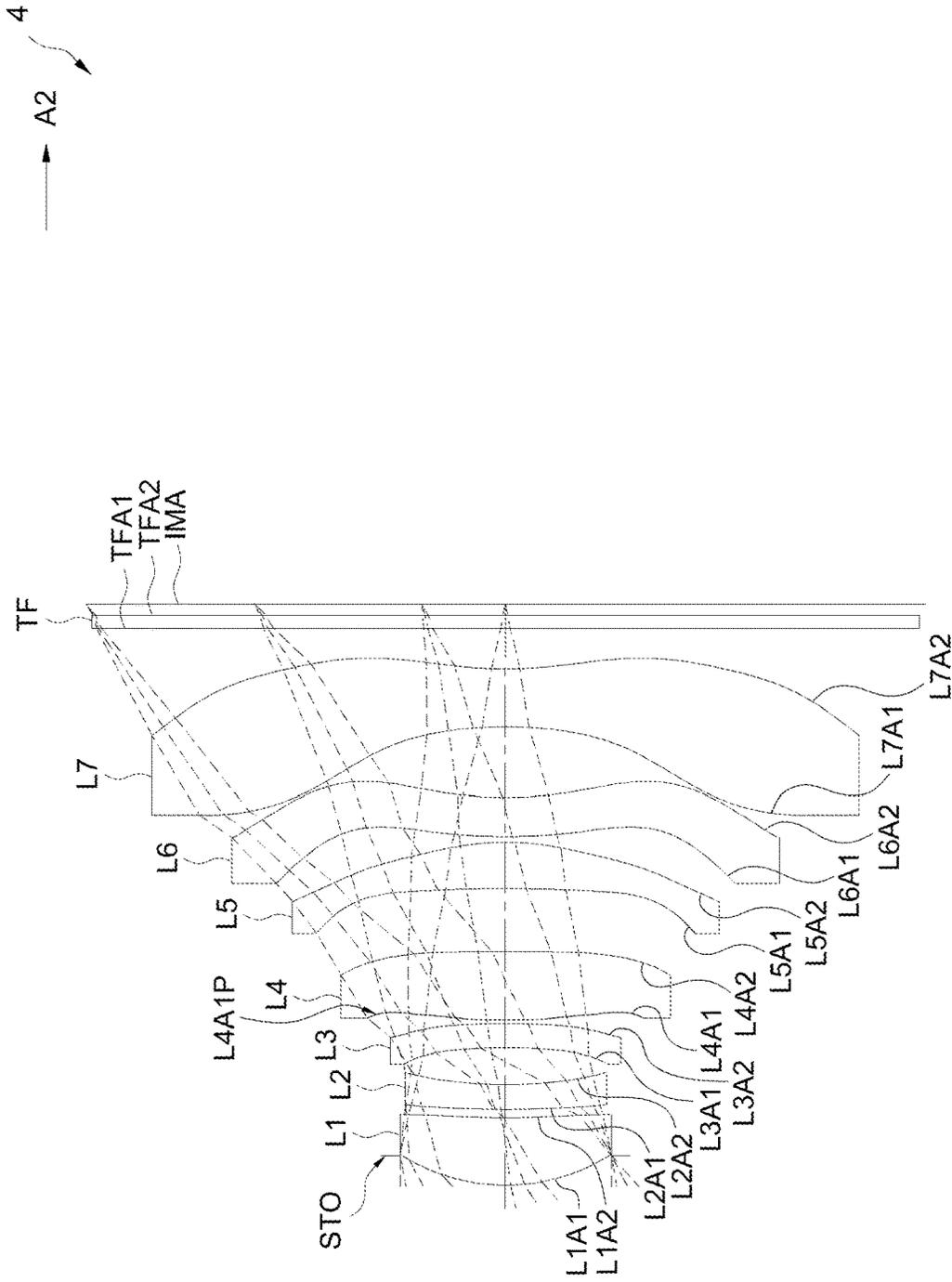


FIG. 18

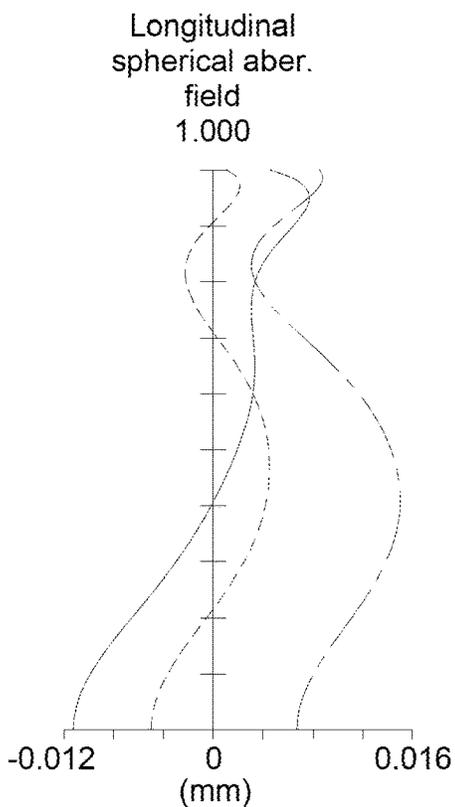


FIG. 19A

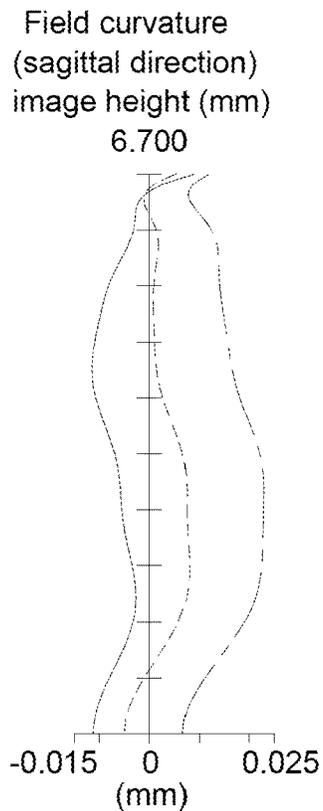
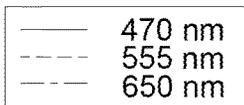


FIG. 19B

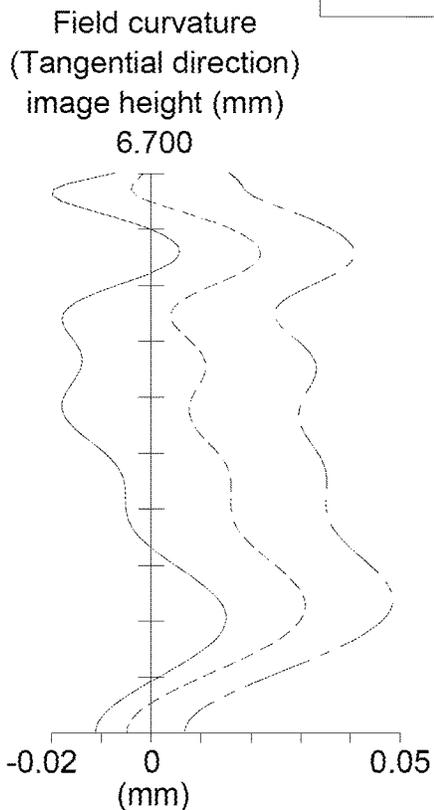


FIG. 19C

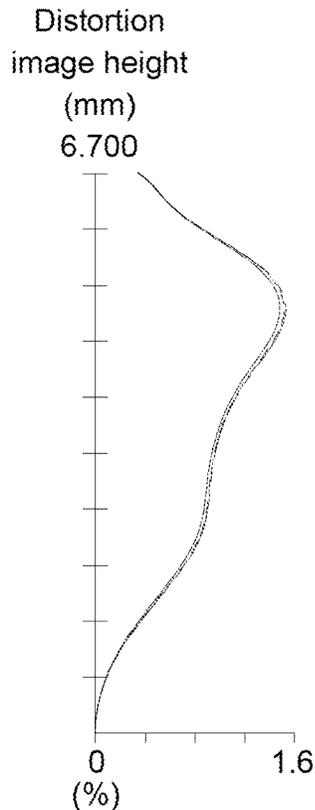


FIG. 19D

Embodiment 4							
EFL = 7.507 mm ; HFOV = 41.622 degrees ; TTL = 9.294 mm							
Fno = 2.230 ; Image Height = 6.700 mm							
Surface #		Radius of curvature (mm)	Thickness /air gap (mm)	Refractive index	Abbe number	Focal length (mm)	Material
OBJ	Object	INFINITY	INFINITY				
STO	Aperture stop	INFINITY	-0.477				
L1A1	1st lens element	3.097	1.083	1.545	55.987	7.113	Plastic
L1A2		13.377	0.133				
L2A1	2nd lens element	15.373	0.394	1.661	20.373	-19.836	Plastic
L2A2		7.039	0.587				
L3A1	3rd lens element	-9.786	0.387	1.661	20.373	-43.979	Plastic
L3A2		-14.917	0.054				
L4A1	4th lens element	11.363	1.093	1.545	55.987	21.988	Plastic
L4A2		203.487	1.009				
L5A1	5th lens element	-32.918	0.744	1.545	55.987	8.211	Plastic
L5A2		-3.979	0.094				
L6A1	6th lens element	12.479	0.621	1.661	20.373	-27.474	Plastic
L6A2		7.276	1.127				
L7A1	7th lens element	-6.156	0.928	1.545	55.987	-5.647	Plastic
L7A2		6.512	0.650				
TFA1	Filtering unit	INFINITY	0.210	1.517	64.167		
TFA2		INFINITY	0.179				
IMA	Image plane	INFINITY					

FIG. 20

Embodiment 4					
Aspherical Parameters					
Surface#	K	a4	a6	a8	a10
L1A1	2.032932E-02	-1.758675E-05	7.590512E-04	-9.939783E-04	5.754145E-04
L1A2	0.000000E+00	-9.901561E-03	4.013129E-04	1.265488E-03	-6.299437E-04
L2A1	0.000000E+00	-9.690940E-03	-4.772505E-04	5.293944E-03	-3.292618E-03
L2A2	4.408451E+00	-2.301489E-03	-4.224130E-04	3.129346E-03	-2.253791E-03
L3A1	0.000000E+00	-4.223690E-03	-7.746062E-03	3.669456E-03	-1.925023E-03
L3A2	0.000000E+00	-1.770056E-02	3.000255E-03	1.491292E-03	-2.094459E-03
L4A1	6.984441E-01	-2.780530E-02	1.361940E-02	-4.897695E-03	1.073199E-03
L4A2	0.000000E+00	-8.414746E-03	-7.590755E-04	8.563711E-04	-4.319875E-04
L5A1	0.000000E+00	-8.307480E-03	5.957200E-03	-1.803920E-03	1.537208E-04
L5A2	-6.277575E-01	1.350557E-02	7.873728E-04	-8.906795E-04	1.806228E-04
L6A1	0.000000E+00	1.811905E-02	-7.427196E-03	6.317179E-04	8.591458E-05
L6A2	0.000000E+00	1.624678E-02	-8.983594E-03	1.618134E-03	-1.718237E-04
L7A1	-1.815058E-03	7.790351E-03	-5.733017E-03	1.107982E-03	-1.051684E-04
L7A2	-6.577206E+00	-4.488609E-03	-1.300415E-03	2.725813E-04	-2.505525E-05
Surface#	a12	a14	a16	a18	a20
L1A1	-1.976609E-04	3.484913E-05	-2.764233E-06	/	/
L1A2	1.194768E-04	8.591396E-07	-2.764932E-06		
L2A1	1.075187E-03	-1.718524E-04	1.032873E-05		
L2A2	7.875427E-04	-1.404190E-04	9.295775E-06		
L3A1	4.549060E-04	-5.677945E-05	6.366319E-06		
L3A2	8.017144E-04	-1.321396E-04	1.010111E-05		
L4A1	-1.318124E-04	8.600678E-06	-2.817064E-07	-2.359168E-07	6.601692E-09
L4A2	1.360663E-04	-2.769900E-05	3.457794E-06	-4.572069E-08	9.021020E-10
L5A1	2.581234E-05	-8.219760E-06	8.991693E-07	6.900327E-09	-1.147700E-10
L5A2	-2.324732E-05	2.377429E-06	-1.707061E-07	3.245257E-09	-1.413700E-11
L6A1	-2.757353E-05	2.943293E-06	-1.495182E-07	6.398600E-11	-1.900000E-12
L6A2	1.099454E-05	-3.863897E-07	5.144336E-09	-5.315700E-11	2.790000E-13
L7A1	5.896375E-06	-2.055396E-07	4.399278E-09	-1.355300E-11	7.400000E-14
L7A2	1.380141E-06	-4.868948E-08	1.077384E-09		

FIG. 21

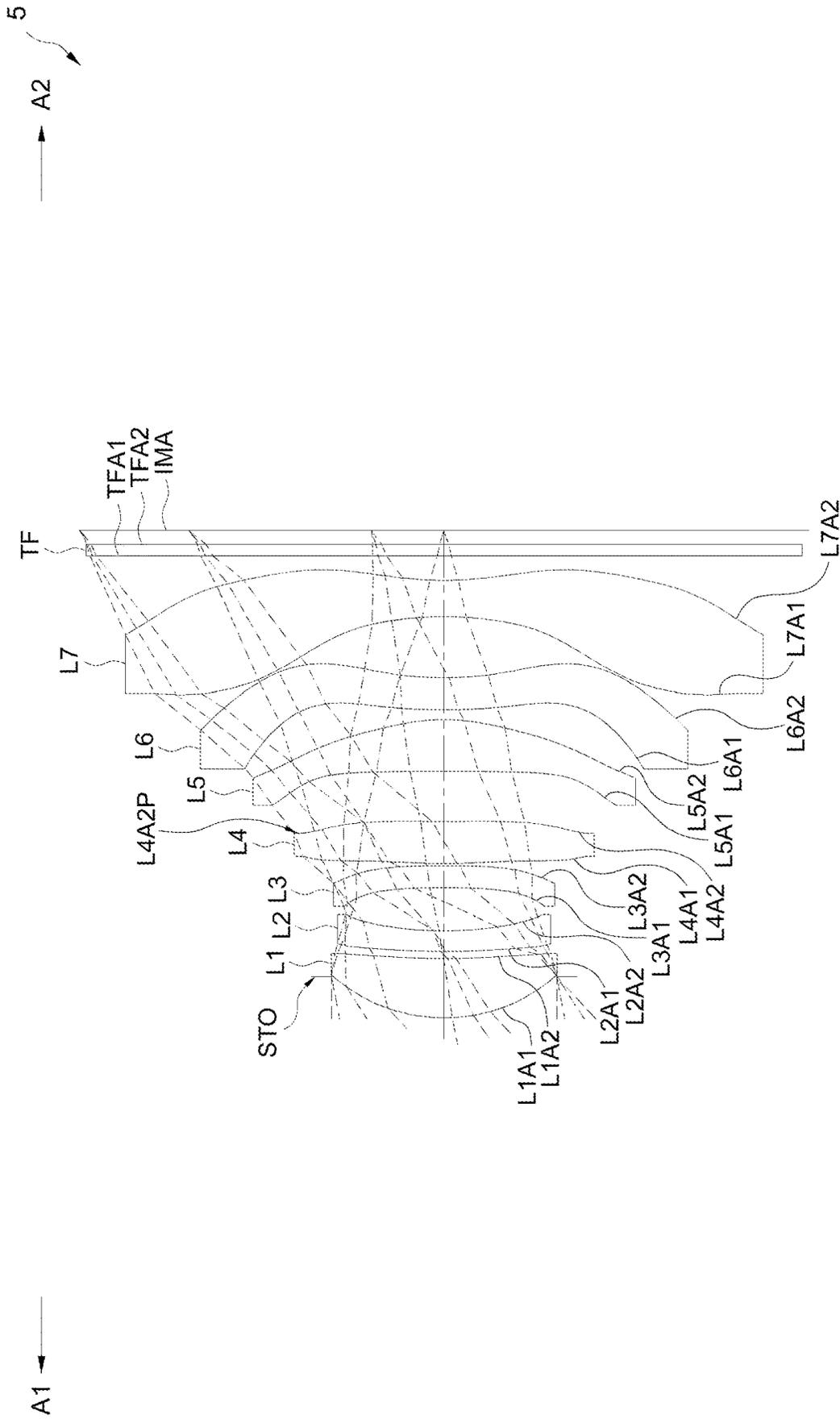


FIG. 22

Longitudinal spherical aberr. field 1.000

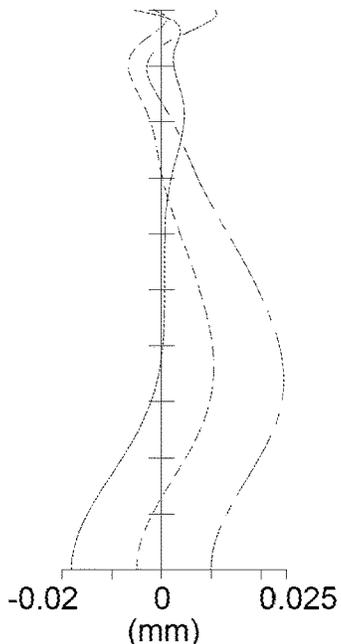


FIG. 23A

Field curvature (sagittal direction) image height (mm) 6.700

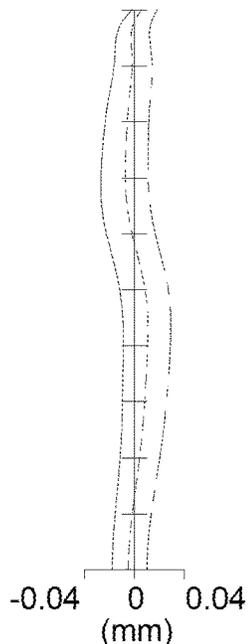


FIG. 23B

Field curvature (Tangential direction) image height (mm) 6.700

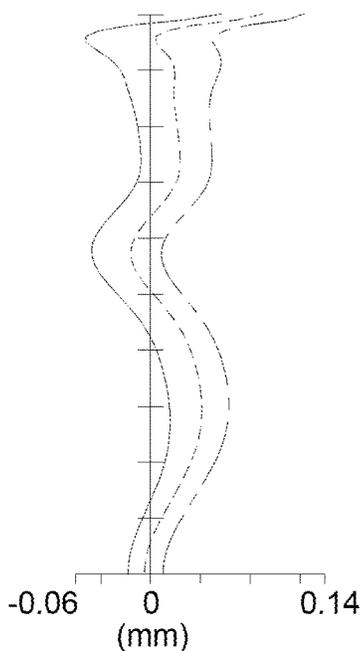


FIG. 23C

Distortion image height (mm) 6.700

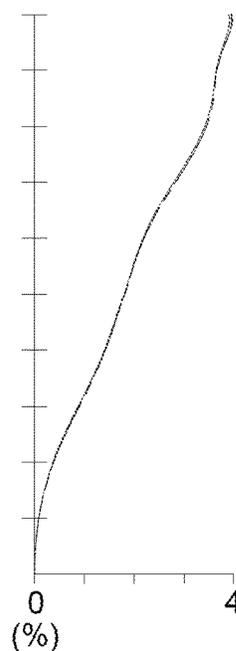


FIG. 23D

—	470 nm
- - -	555 nm
- · - ·	650 nm

Embodiment 5							
EFL = 7.033 mm ; HFOV = 42.473 degrees ; TTL = 8.978 mm							
Fno = 1.700 ; Image Height = 6.700 mm							
Surface #		Radius of curvature (mm)	Thickness /air gap (mm)	Refractive index	Abbe number	Focal length (mm)	Material
OBJ	Object	INFINITY	INFINITY				
STO	Aperture stop	INFINITY	-0.764				
L1A1	1st lens element	3.151	1.093	1.545	55.987	7.448	Plastic
L1A2		12.256	0.130				
L2A1	2nd lens element	11.533	0.379	1.661	20.373	-22.322	Plastic
L2A2		6.414	0.789				
L3A1	3rd lens element	-15.251	0.404	1.661	20.373	-48.508	Plastic
L3A2		-29.152	0.043				
L4A1	4th lens element	10.202	0.778	1.545	55.987	22.574	Plastic
L4A2		57.484	0.926				
L5A1	5th lens element	-102.623	0.951	1.545	55.987	6.864	Plastic
L5A2		-3.629	0.185				
L6A1	6th lens element	15.743	0.580	1.661	20.373	-20.841	Plastic
L6A2		7.274	1.128				
L7A1	7th lens element	-6.158	0.670	1.545	55.987	-5.491	Plastic
L7A2		6.072	0.450				
TFA1	Filtering unit	INFINITY	0.210	1.517	64.167		
TFA2		INFINITY	0.263				
IMA	Image plane	INFINITY					

FIG. 24

Embodiment 5					
Aspherical Parameters					
Surface#	K	a4	a6	a8	a10
L1A1	8.638233E-02	-1.318566E-04	1.457689E-03	-1.254179E-03	6.273820E-04
L1A2	0.000000E+00	-7.402059E-03	1.422296E-04	1.100201E-03	-5.064756E-04
L2A1	0.000000E+00	-1.048973E-02	-1.727909E-03	5.576247E-03	-3.347080E-03
L2A2	1.522730E+00	-2.949802E-03	-7.503360E-04	3.757551E-03	-2.435651E-03
L3A1	0.000000E+00	-4.495903E-03	-7.891398E-03	3.884621E-03	-1.827817E-03
L3A2	0.000000E+00	-1.878718E-02	2.565621E-03	1.495406E-03	-2.083969E-03
L4A1	4.466330E-01	-2.788960E-02	1.368699E-02	-4.899195E-03	1.071985E-03
L4A2	0.000000E+00	-8.833175E-03	-5.973571E-04	8.521141E-04	-4.313238E-04
L5A1	0.000000E+00	-8.379357E-03	5.852966E-03	-1.795529E-03	1.548028E-04
L5A2	-6.698880E-01	1.367650E-02	8.119351E-04	-8.895054E-04	1.804940E-04
L6A1	0.000000E+00	1.852670E-02	-7.479604E-03	6.291865E-04	8.594708E-05
L6A2	0.000000E+00	1.652821E-02	-9.011572E-03	1.617415E-03	-1.718190E-04
L7A1	3.710326E-03	7.748688E-03	-5.733537E-03	1.107982E-03	-1.051685E-04
L7A2	-6.726508E+00	-4.361736E-03	-1.301019E-03	2.725982E-04	-2.505492E-05
Surface#	a12	a14	a16	a18	a20
L1A1	-1.758863E-04	2.641615E-05	-1.779963E-06	\	\
L1A2	1.025316E-04	-1.082828E-05	5.114775E-07		
L2A1	1.042639E-03	-1.689854E-04	1.157580E-05		
L2A2	8.060003E-04	-1.357769E-04	9.447947E-06		
L3A1	4.284109E-04	-5.090714E-05	2.689043E-06		
L3A2	7.961623E-04	-1.374781E-04	9.716202E-06		
L4A1	-1.325024E-04	8.743166E-06	-2.425169E-07		
L4A2	1.361555E-04	-2.768544E-05	3.464850E-06	-2.342288E-07	6.450513E-09
L5A1	2.587556E-05	-8.216657E-06	8.991206E-07	-4.571970E-08	8.980000E-10
L5A2	-2.325736E-05	2.378031E-06	-1.706004E-07	6.905771E-09	-1.152510E-10
L6A1	-2.758202E-05	2.942574E-06	-1.495516E-07	3.245996E-09	-1.396200E-11
L6A2	1.099511E-05	-3.863899E-07	5.143936E-09	6.394700E-11	-1.906000E-12
L7A1	5.896370E-06	-2.055390E-07	4.399294E-09	-5.315700E-11	2.790000E-13
L7A2	1.380153E-06	-4.868917E-08	1.077388E-09	-1.355300E-11	7.400000E-14

FIG. 25

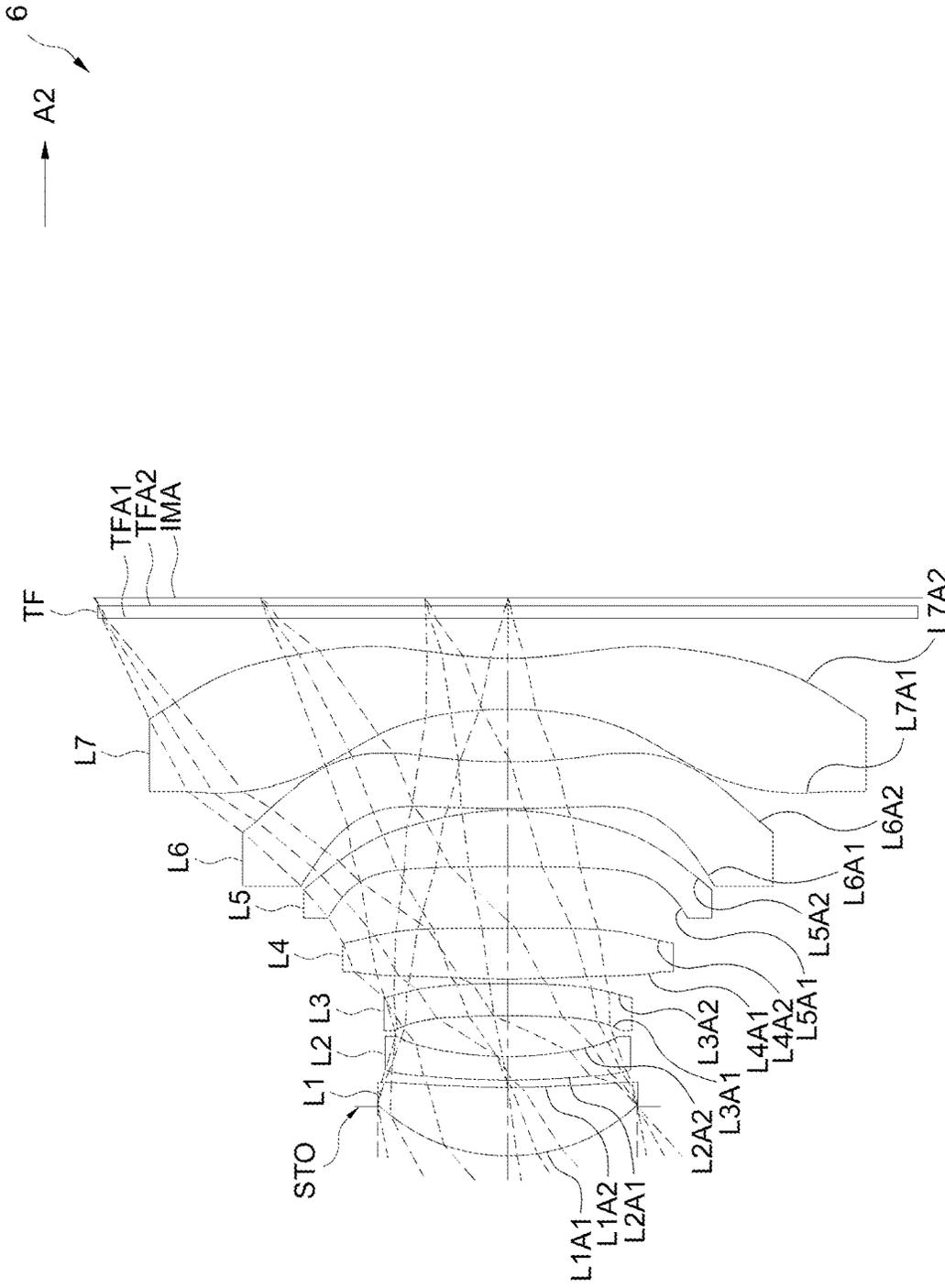


FIG. 26

Longitudinal spherical aber. field 1.000

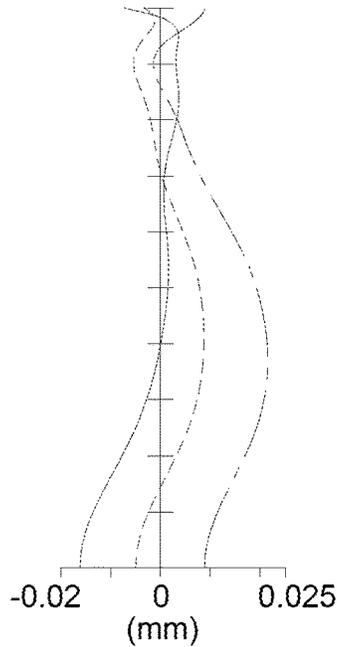


FIG. 27A

Field curvature (sagittal direction) image height (mm) 6.700

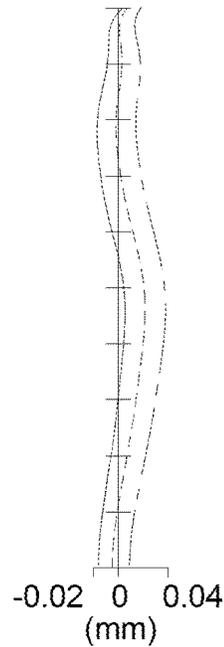


FIG. 27B

—	470 nm
- - -	555 nm
- · - ·	650 nm

Field curvature (Tangential direction) image height (mm) 6.700

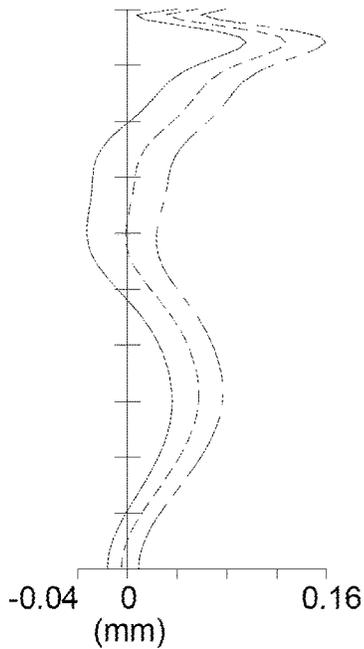


FIG. 27C

Distortion image height (mm) 6.700

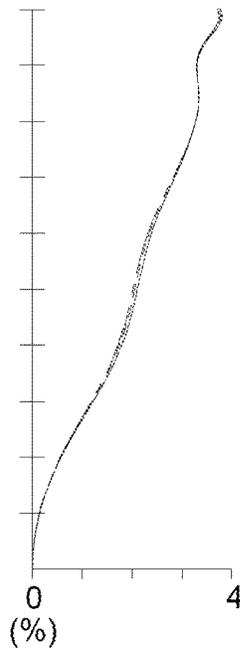


FIG. 27D

Embodiment 6							
EFL = 7.164 mm ; HFOV = 42.003 degrees ; TTL = 9.058 mm							
Fno = 1.703 ; Image Height = 6.700 mm							
Surface #		Radius of curvature (mm)	Thickness /air gap (mm)	Refractive index	Abbe number	Focal length (mm)	Material
OBJ	Object	INFINITY	INFINITY				
STO	Aperture stop	INFINITY	-0.801				
L1A1	1st lens element	3.098	1.114	1.545	55.987	7.034	Plastic
L1A2		13.963	0.119				
L2A1	2nd lens element	10.913	0.384	1.661	20.373	-19.567	Plastic
L2A2		5.860	0.657				
L3A1	3rd lens element	-20.129	0.516	1.661	20.373	-70.023	Plastic
L3A2		-35.733	0.074				
L4A1	4th lens element	9.778	0.830	1.545	55.987	20.074	Plastic
L4A2		87.555	1.002				
L5A1	5th lens element	-95.957	0.915	1.545	55.987	8.053	Plastic
L5A2		-4.220	0.028				
L6A1	6th lens element	33.197	0.751	1.661	20.373	-26.065	Plastic
L6A2		11.308	0.855				
L7A1	7th lens element	-6.307	0.829	1.545	55.987	-5.471	Plastic
L7A2		5.945	0.650				
TFA1	Filtering unit	INFINITY	0.210	1.517	64.167		
TFA2		INFINITY	0.122				
IMA	Image plane	INFINITY					

FIG. 28

Embodiment 6					
Aspherical Parameters					
Surface#	K	a4	a6	a8	a10
L1A1	9.415180E-02	-4.595079E-04	1.479081E-03	-1.266782E-03	6.146797E-04
L1A2	0.000000E+00	-7.989041E-03	1.139150E-03	8.726972E-04	-5.279156E-04
L2A1	0.000000E+00	-1.052123E-02	-1.465620E-03	5.690336E-03	-3.406677E-03
L2A2	-4.226268E-02	-2.185891E-03	-8.774760E-04	3.858538E-03	-2.457093E-03
L3A1	0.000000E+00	-3.686326E-03	-6.474368E-03	3.934467E-03	-1.875325E-03
L3A2	0.000000E+00	-1.972162E-02	3.716482E-03	1.667639E-03	-2.097795E-03
L4A1	-3.691826E+00	-2.809220E-02	1.370452E-02	-4.858881E-03	1.073562E-03
L4A2	0.000000E+00	-7.328713E-03	-7.832429E-04	8.448362E-04	-4.324590E-04
L5A1	0.000000E+00	-9.702538E-03	5.832246E-03	-1.825078E-03	1.548931E-04
L5A2	-1.569637E-01	1.057411E-02	6.486678E-04	-8.821129E-04	1.805858E-04
L6A1	0.000000E+00	1.410852E-02	-7.287930E-03	6.201867E-04	8.563106E-05
L6A2	0.000000E+00	1.682403E-02	-9.017885E-03	1.617305E-03	-1.718186E-04
L7A1	5.854421E-02	7.879159E-03	-5.734224E-03	1.107945E-03	-1.051703E-04
L7A2	-8.302085E+00	-4.055850E-03	-1.308944E-03	2.725819E-04	-2.505457E-05
Surface#	a12	a14	a16	a18	a20
L1A1	-1.701120E-04	2.554473E-05	-1.757015E-06	/	/
L1A2	1.179772E-04	-1.270177E-05	5.177180E-07		
L2A1	1.025460E-03	-1.583570E-04	1.031800E-05		
L2A2	7.803615E-04	-1.245704E-04	8.231718E-06		
L3A1	4.336032E-04	-4.585325E-05	1.507433E-06		
L3A2	7.792436E-04	-1.320112E-04	9.153787E-06		
L4A1	-1.332134E-04	8.694051E-06	-2.366329E-07		
L4A2	1.367781E-04	-2.765087E-05	3.461481E-06	-2.373704E-07	6.706089E-09
L5A1	2.576772E-05	-8.242669E-06	8.973667E-07	-4.583073E-08	9.410270E-10
L5A2	-2.321245E-05	2.380524E-06	-1.704236E-07	6.892828E-09	-1.180340E-10
L6A1	-2.760874E-05	2.941416E-06	-1.494007E-07	3.255713E-09	-1.174200E-11
L6A2	1.099591E-05	-3.863397E-07	5.147055E-09	6.401500E-11	-1.901000E-12
L7A1	5.896353E-06	-2.055396E-07	4.399313E-09	-5.315600E-11	2.790000E-13
L7A2	1.380189E-06	-4.868820E-08	1.077398E-09	-1.355300E-11	7.400000E-14

FIG. 29

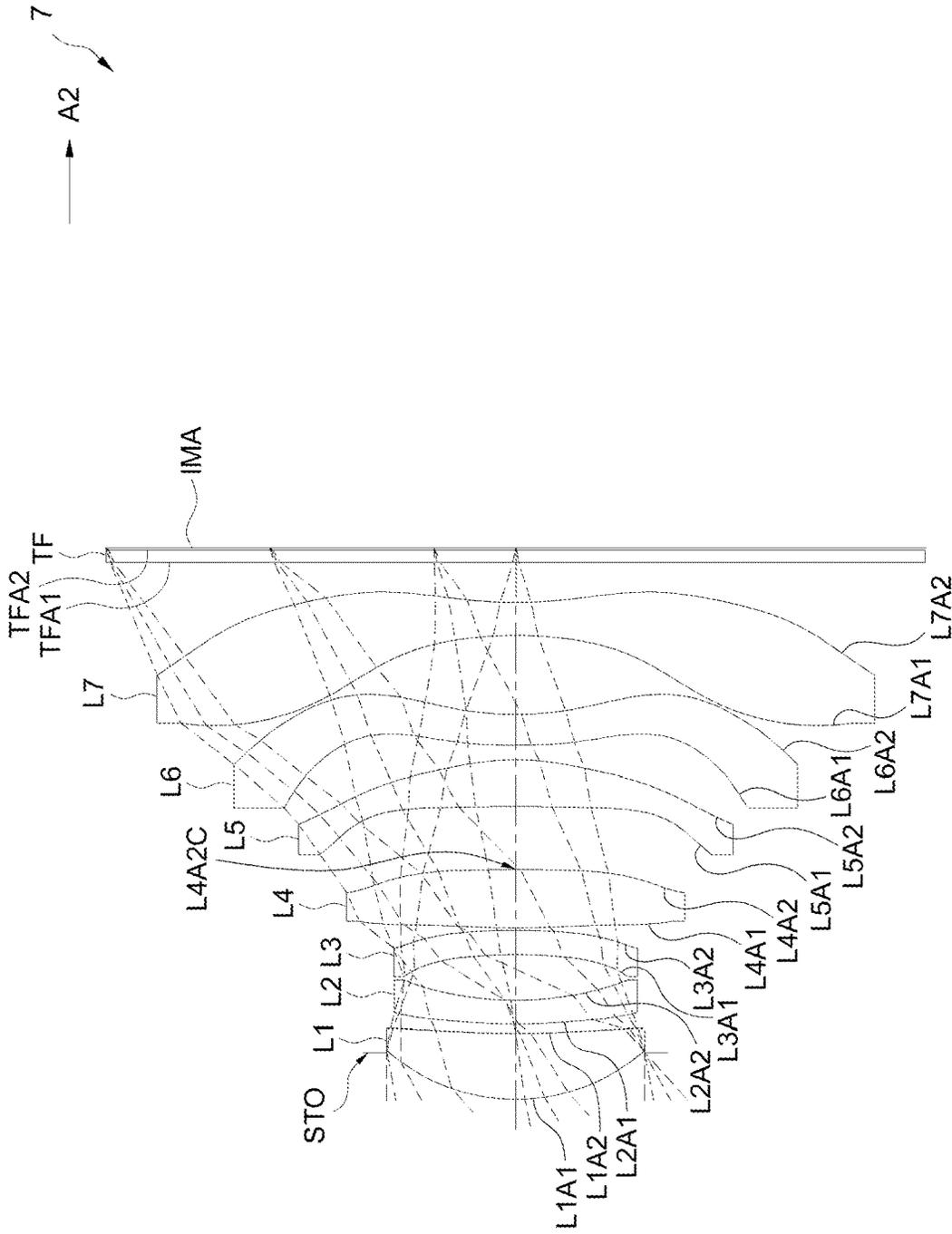


FIG. 30

Longitudinal spherical aberr. field 1.000

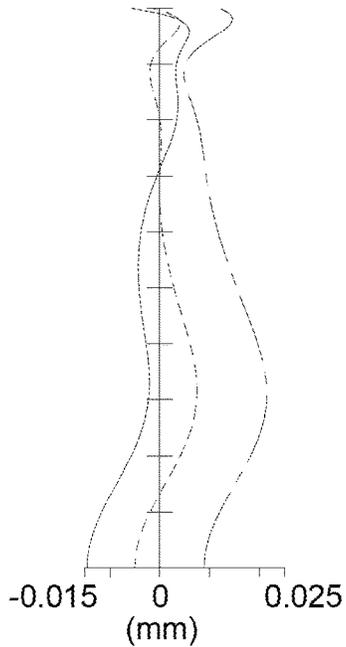


FIG. 31A

Field curvature (sagittal direction) image height (mm) 6.700

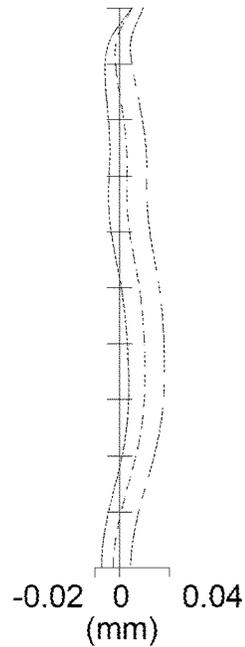


FIG. 31B

—	470 nm
- - -	555 nm
- · - ·	650 nm

Field curvature (Tangential direction) image height (mm) 6.700

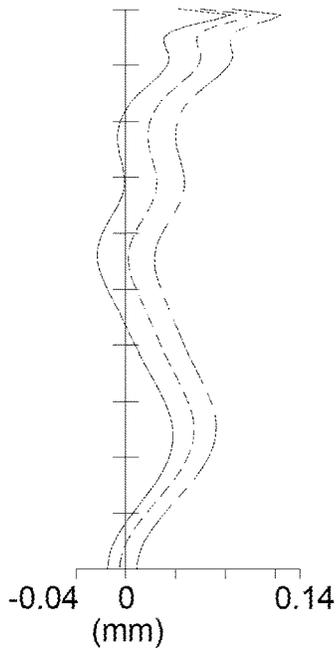


FIG. 31C

Distortion image height (mm) 6.700

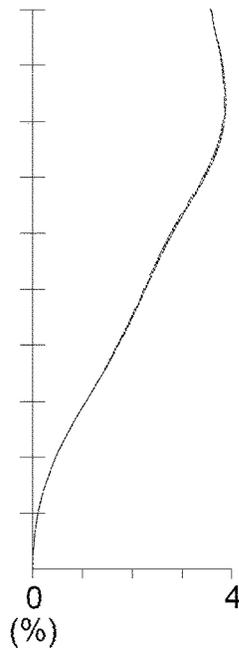


FIG. 31D

Embodiment 7							
EFL = 7.180 mm ; HFOV = 41.982 degrees ; TTL = 9.025 mm							
Fno = 1.705 ; Image Height = 6.700 mm							
Surface #		Radius of curvature (mm)	Thickness /air gap (mm)	Refractive index	Abbe number	Focal length (mm)	Material
OBJ	Object	INFINITY	INFINITY				
STO	Aperture stop	INFINITY	-0.768				
L1A1	1st lens element	3.213	1.079	1.545	55.987	7.221	Plastic
L1A2		15.270	0.150				
L2A1	2nd lens element	9.441	0.386	1.661	20.373	-18.862	Plastic
L2A2		5.306	0.751				
L3A1	3rd lens element	-8.773	0.398	1.671	19.243	-37.271	Plastic
L3A2		-13.690	0.040				
L4A1	4th lens element	10.907	0.955	1.523	54.517	17.644	Plastic
L4A2		-59.653	1.034				
L5A1	5th lens element	-89.418	0.757	1.523	54.517	8.158	Plastic
L5A2		-4.099	0.240				
L6A1	6th lens element	10.678	0.509	1.588	28.433	-25.138	Plastic
L6A2		6.106	1.294				
L7A1	7th lens element	-6.145	0.542	1.545	55.987	-5.754	Plastic
L7A2		6.635	0.650				
TFA1	Filtering unit	INFINITY	0.210	1.517	64.167		
TFA2		INFINITY	0.031				
IMA	Image plane	INFINITY					

FIG. 32

Embodiment 7					
Aspherical Parameters					
Surface#	K	a4	a6	a8	a10
L1A1	1.043673E-01	-4.024353E-04	1.447135E-03	-1.268915E-03	6.257064E-04
L1A2	0.000000E+00	-5.807911E-03	3.507567E-04	9.446875E-04	-4.912761E-04
L2A1	0.000000E+00	-9.882730E-03	-1.751460E-03	5.500233E-03	-3.344342E-03
L2A2	4.693607E-01	-3.917282E-03	-9.687829E-04	3.867446E-03	-2.499655E-03
L3A1	0.000000E+00	-2.450308E-03	-7.539684E-03	3.967741E-03	-1.849031E-03
L3A2	0.000000E+00	-1.678208E-02	2.791226E-03	1.614517E-03	-2.070033E-03
L4A1	3.375240E+00	-2.722193E-02	1.362563E-02	-4.910157E-03	1.072491E-03
L4A2	0.000000E+00	-8.018750E-03	-7.384982E-04	8.553617E-04	-4.325871E-04
L5A1	0.000000E+00	-8.926872E-03	5.876899E-03	-1.798306E-03	1.543441E-04
L5A2	-5.429098E-01	1.304847E-02	8.006165E-04	-8.926718E-04	1.805065E-04
L6A1	0.000000E+00	1.855503E-02	-7.505203E-03	6.380687E-04	8.586017E-05
L6A2	0.000000E+00	1.634741E-02	-9.013931E-03	1.617335E-03	-1.718259E-04
L7A1	6.194337E-03	7.687826E-03	-5.734010E-03	1.107986E-03	-1.051681E-04
L7A2	-5.412784E+00	-4.661624E-03	-1.300829E-03	2.726280E-04	-2.505381E-05
Surface#	a12	a14	a16	a18	a20
L1A1	-1.738824E-04	2.550306E-05	-1.631163E-06	\	\
L1A2	1.063980E-04	-1.110177E-05	4.281697E-07		
L2A1	1.044970E-03	-1.683123E-04	1.137547E-05		
L2A2	7.931380E-04	-1.227907E-04	7.114012E-06		
L3A1	4.509476E-04	-5.423944E-05	2.508644E-06		
L3A2	7.983671E-04	-1.398231E-04	1.006746E-05		
L4A1	-1.321921E-04	8.655652E-06	-2.370456E-07	-2.345638E-07	6.480187E-09
L4A2	1.360396E-04	-2.766671E-05	3.464833E-06	-4.572312E-08	9.013840E-10
L5A1	2.584139E-05	-8.217304E-06	8.990472E-07	6.905346E-09	-1.145650E-10
L5A2	-2.325213E-05	2.377405E-06	-1.706250E-07	3.247279E-09	-1.404000E-11
L6A1	-2.759685E-05	2.942085E-06	-1.495604E-07	6.394300E-11	-1.909000E-12
L6A2	1.099508E-05	-3.863860E-07	5.144195E-09	-5.315800E-11	2.790000E-13
L7A1	5.896403E-06	-2.055386E-07	4.399296E-09	-1.355300E-11	7.400000E-14
L7A2	1.380175E-06	-4.868881E-08	1.077386E-09		

FIG. 33

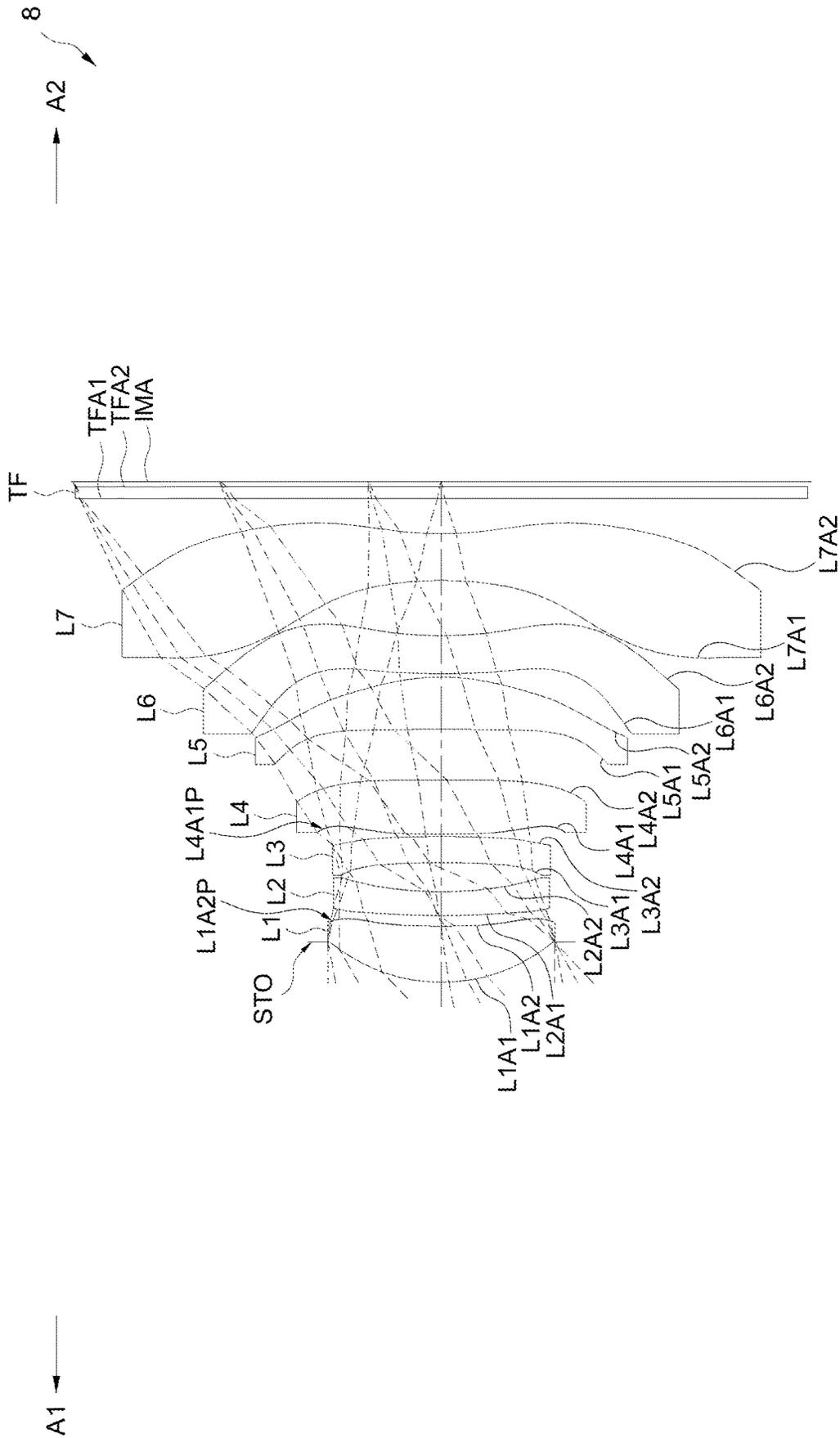


FIG. 34

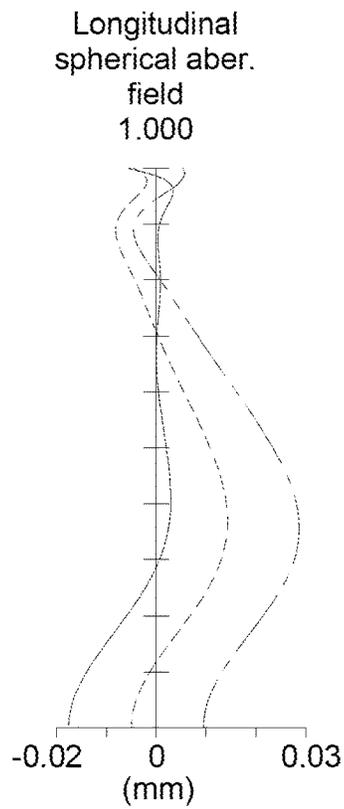


FIG. 35A

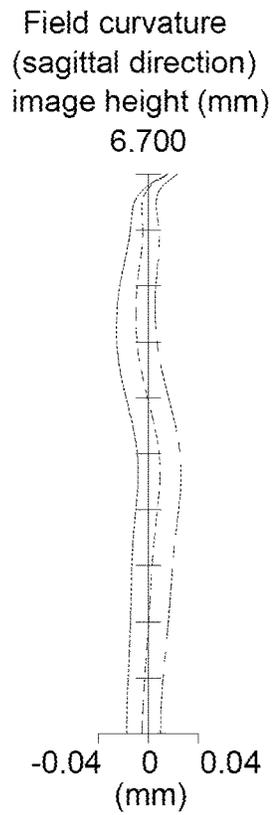


FIG. 35B

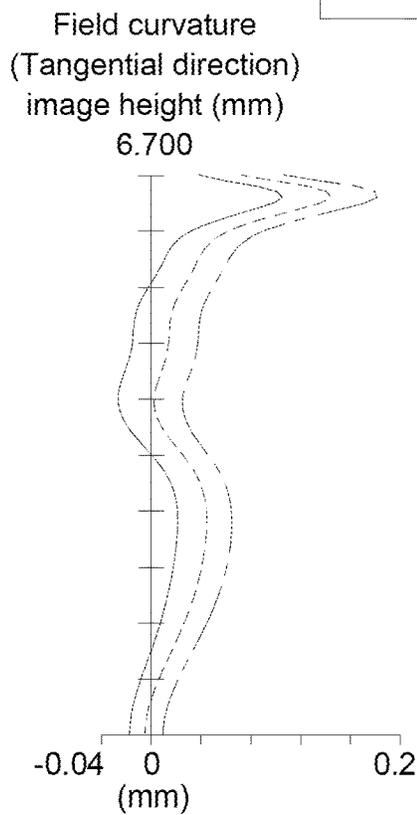


FIG. 35C

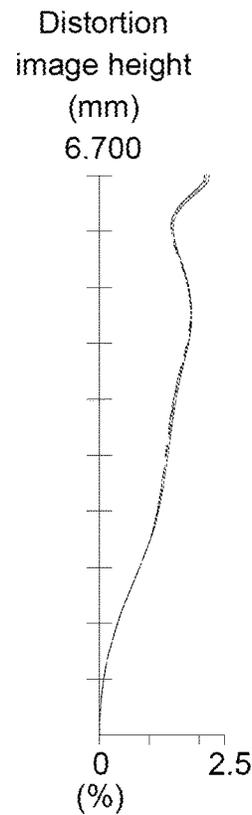
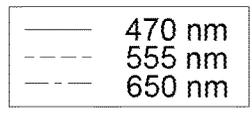


FIG. 35D

Embodiment 8							
EFL = 7.024 mm ; HFOV = 43.007 degrees ; TTL = 9.098 mm							
Fno = 1.706 ; Image Height = 6.700 mm							
Surface #		Radius of curvature (mm)	Thickness /air gap (mm)	Refractive index	Abbe number	Focal length (mm)	Material
OBJ	Object	INFINITY	INFINITY				
STO	Aperture stop	INFINITY	-0.734				
L1A1	1st lens element	3.175	1.009	1.545	55.987	7.506	Plastic
L1A2		12.492	0.194				
L2A1	2nd lens element	11.629	0.435	1.661	20.373	-21.906	Plastic
L2A2		6.379	0.531				
L3A1	3rd lens element	-20.876	0.474	1.661	20.373	-57.649	Plastic
L3A2		-46.078	0.039				
L4A1	4th lens element	10.302	0.989	1.545	55.987	20.918	Plastic
L4A2		101.115	0.928				
L5A1	5th lens element	-113.398	0.940	1.545	55.987	7.163	Plastic
L5A2		-3.794	0.062				
L6A1	6th lens element	17.543	0.692	1.661	20.373	-23.439	Plastic
L6A2		8.137	1.007				
L7A1	7th lens element	-6.183	0.849	1.545	55.987	-5.444	Plastic
L7A2		6.008	0.650				
TFA1	Filtering unit	INFINITY	0.210	1.517	64.167		
TFA2		INFINITY	0.088				
IMA	Image plane	INFINITY					

FIG. 36

Embodiment 8					
Aspherical Parameters					
Surface#	K	a4	a6	a8	a10
L1A1	5.314312E-02	-4.779410E-04	1.517251E-03	-1.268541E-03	6.107597E-04
L1A2	0.000000E+00	-6.586195E-03	-7.430939E-05	1.010437E-03	-4.789366E-04
L2A1	0.000000E+00	-1.117194E-02	-1.730597E-03	5.566760E-03	-3.322066E-03
L2A2	-1.896397E+00	-4.092840E-03	-7.196261E-04	3.838034E-03	-2.493376E-03
L3A1	0.000000E+00	-7.568798E-04	-7.143041E-03	3.915176E-03	-1.880310E-03
L3A2	0.000000E+00	-1.507671E-02	3.525082E-03	1.576666E-03	-2.105934E-03
L4A1	-1.771827E-01	-2.771209E-02	1.374537E-02	-4.907219E-03	1.062835E-03
L4A2	0.000000E+00	-7.785795E-03	-9.776089E-04	8.501923E-04	-4.305662E-04
L5A1	0.000000E+00	-8.789139E-03	6.009954E-03	-1.810487E-03	1.538669E-04
L5A2	-4.822692E-01	1.218403E-02	8.006960E-04	-8.871408E-04	1.808739E-04
L6A1	0.000000E+00	1.638236E-02	-7.457653E-03	6.245022E-04	8.579534E-05
L6A2	0.000000E+00	1.610930E-02	-9.000315E-03	1.617698E-03	-1.718352E-04
L7A1	8.369307E-04	7.774053E-03	-5.733329E-03	1.107976E-03	-1.051690E-04
L7A2	-5.886011E+00	-4.402052E-03	-1.301239E-03	2.725771E-04	-2.505565E-05
Surface#	a12	a14	a16	a18	a20
L1A1	-1.732443E-04	2.669512E-05	-1.908958E-06	\	\
L1A2	1.032772E-04	-1.171086E-05	5.051056E-07		
L2A1	1.044313E-03	-1.711788E-04	1.185248E-05		
L2A2	7.896991E-04	-1.215770E-04	6.666635E-06		
L3A1	4.507981E-04	-5.229497E-05	2.008280E-06		
L3A2	7.940532E-04	-1.356739E-04	9.533650E-06		
L4A1	-1.333719E-04	9.472193E-06	-3.687767E-07	-2.366142E-07	6.563799E-09
L4A2	1.363602E-04	-2.769598E-05	3.455546E-06	-4.573163E-08	8.975000E-10
L5A1	2.585435E-05	-8.216031E-06	8.990497E-07	6.898199E-09	-1.165930E-10
L5A2	-2.322957E-05	2.379235E-06	-1.705907E-07	3.251042E-09	-1.381200E-11
L6A1	-2.757780E-05	2.943613E-06	-1.494663E-07	6.410200E-11	-1.894000E-12
L6A2	1.099424E-05	-3.863903E-07	5.145605E-09	-5.315700E-11	2.790000E-13
L7A1	5.896360E-06	-2.055396E-07	4.399280E-09	-1.355300E-11	7.400000E-14
L7A2	1.380142E-06	-4.868956E-08	1.077381E-09		

FIG. 37

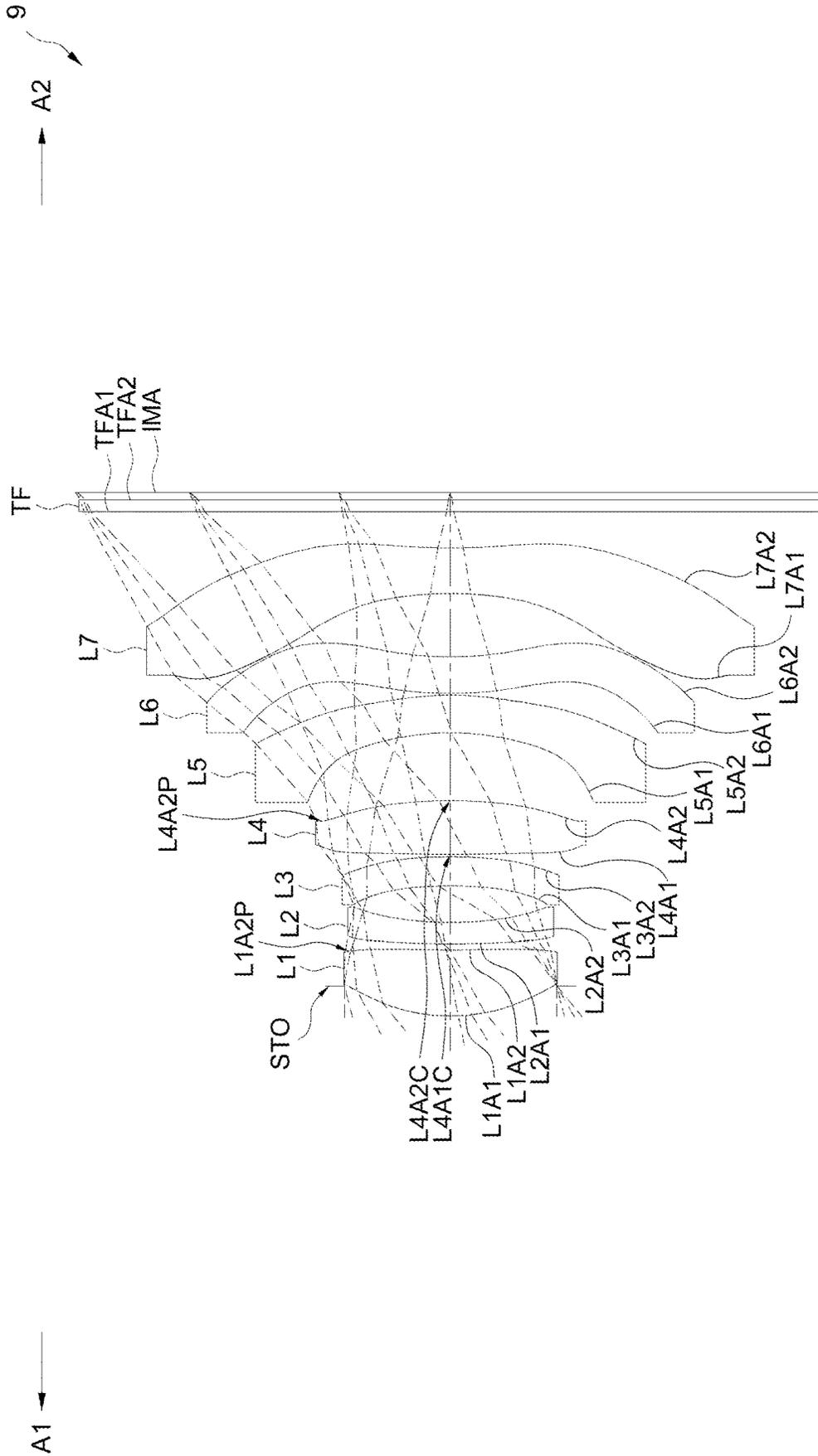


FIG. 38

Longitudinal spherical aber. field 1.000

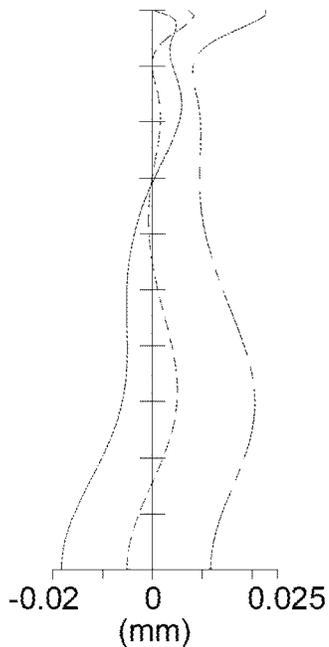


FIG. 39A

Field curvature (sagittal direction) image height (mm) 6.700

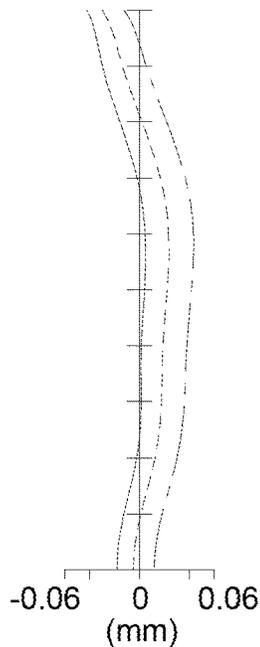


FIG. 39B

Field curvature (Tangential direction) image height (mm) 6.700

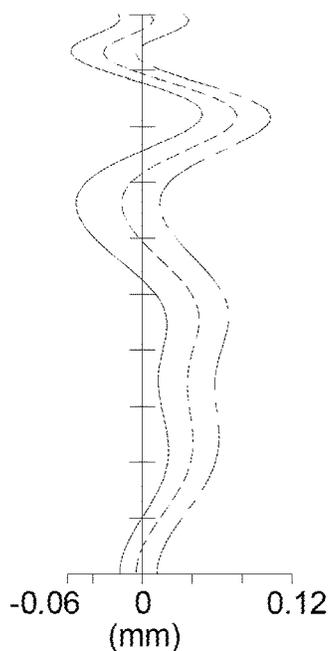


FIG. 39C

Distortion image height (mm) 6.700

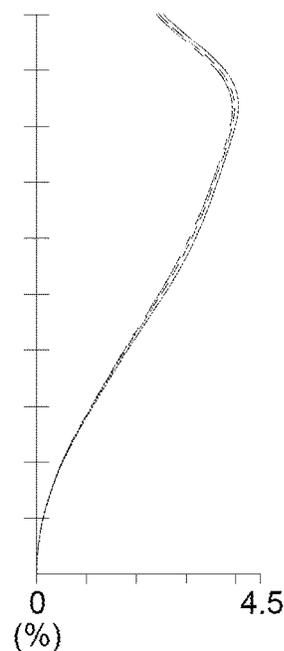
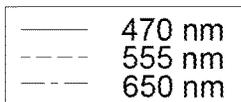


FIG. 39D



Embodiment 9							
EFL = 8.029 mm ; HFOV = 39.135 degrees ; TTL = 9.431 mm							
Fno = 2.105 ; Image Height = 6.700 mm							
Surface #		Radius of curvature (mm)	Thickness /air gap (mm)	Refractive index	Abbe number	Focal length (mm)	Material
OBJ	Object	INFINITY	INFINITY				
STO	Aperture stop	INFINITY	-0.548				
L1A1	1st lens element	3.229	1.190	1.545	55.987	6.844	Plastic
L1A2		20.599	0.113				
L2A1	2nd lens element	13.553	0.381	1.661	20.373	-21.046	Plastic
L2A2		6.818	0.657				
L3A1	3rd lens element	-6.864	0.525	1.661	20.373	-33.983	Plastic
L3A2		-10.146	0.045				
L4A1	4th lens element	14.390	0.966	1.545	55.987	10.551	Plastic
L4A2		-9.386	1.226				
L5A1	5th lens element	-4.995	0.674	1.567	37.490	-5022.252	Plastic
L5A2		-5.249	0.031				
L6A1	6th lens element	8.009	0.663	1.661	20.373	-363.018	Plastic
L6A2		7.496	1.143				
L7A1	7th lens element	-6.049	0.823	1.545	55.987	-6.897	Plastic
L7A2		10.470	0.650				
TFA1	Filtering unit	INFINITY	0.210	1.517	64.167		
TFA2		INFINITY	0.135				
IMA	Image plane	INFINITY					

FIG. 40

Embodiment 9					
Aspherical Parameters					
Surface#	K	a4	a6	a8	a10
L1A1	-2.433362E-02	-1.127859E-03	8.462944E-04	-1.132753E-03	5.877350E-04
L1A2	0.000000E+00	-1.356258E-02	1.402722E-03	1.081239E-03	-6.404719E-04
L2A1	0.000000E+00	-1.051795E-02	1.136070E-04	4.867840E-03	-3.287720E-03
L2A2	5.209585E+00	3.327064E-04	-7.838489E-04	3.224560E-03	-2.370893E-03
L3A1	0.000000E+00	-4.403402E-04	-7.435083E-03	4.052630E-03	-1.874657E-03
L3A2	0.000000E+00	-1.925114E-02	3.393236E-03	1.721191E-03	-2.050027E-03
L4A1	9.449408E+00	-2.711986E-02	1.381927E-02	-4.850003E-03	1.087999E-03
L4A2	0.000000E+00	-4.015468E-03	-7.364748E-04	7.975549E-04	-4.367308E-04
L5A1	0.000000E+00	-5.172833E-03	5.803774E-03	-1.930293E-03	1.401420E-04
L5A2	4.808316E-02	1.233425E-02	7.863141E-04	-8.914091E-04	1.805123E-04
L6A1	0.000000E+00	1.497439E-02	-7.166621E-03	6.305683E-04	8.568871E-05
L6A2	0.000000E+00	1.655558E-02	-9.020981E-03	1.620205E-03	-1.717970E-04
L7A1	-8.206812E-03	7.742178E-03	-5.732644E-03	1.108035E-03	-1.051673E-04
L7A2	-1.832190E+01	-4.531695E-03	-1.302354E-03	2.725876E-04	-2.505391E-05
Surface#	a12	a14	a16	a18	a20
L1A1	-1.823911E-04	2.726169E-05	-1.785302E-06	\	\
L1A2	8.677892E-05	8.121532E-06	-2.098247E-06		
L2A1	1.089809E-03	-1.811706E-04	1.273893E-05		
L2A2	8.408799E-04	-1.472505E-04	1.004552E-05		
L3A1	4.408181E-04	-4.113359E-05	-1.103537E-06		
L3A2	7.919030E-04	-1.381762E-04	9.550101E-06		
L4A1	-1.321749E-04	8.263085E-06	-2.021105E-07		
L4A2	1.369079E-04	-2.745453E-05	3.494269E-06	-2.332390E-07	6.885499E-09
L5A1	2.537641E-05	-8.159936E-06	9.099761E-07	-4.544010E-08	5.969860E-10
L5A2	-2.325312E-05	2.377662E-06	-1.706452E-07	6.904567E-09	-1.148970E-10
L6A1	-2.758456E-05	2.943199E-06	-1.495165E-07	3.245028E-09	-1.440200E-11
L6A2	1.099317E-05	-3.865001E-07	5.139379E-09	6.381600E-11	-1.900000E-12
L7A1	5.896374E-06	-2.055412E-07	4.399143E-09	-5.315900E-11	2.790000E-13
L7A2	1.380198E-06	-4.868764E-08	1.077433E-09	-1.355100E-11	7.400000E-14

FIG. 41

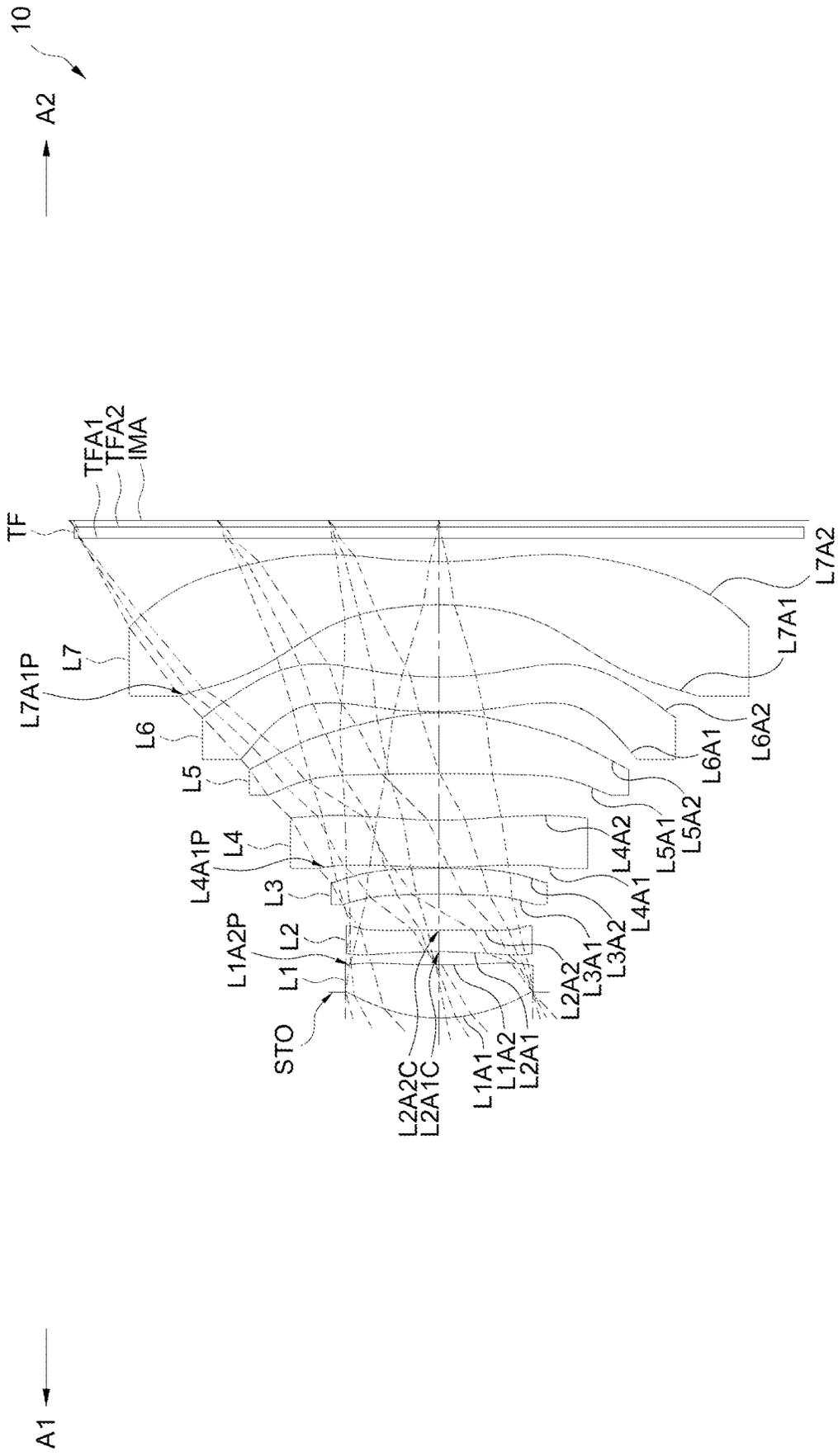


FIG. 42

Longitudinal spherical aber. field 1.000

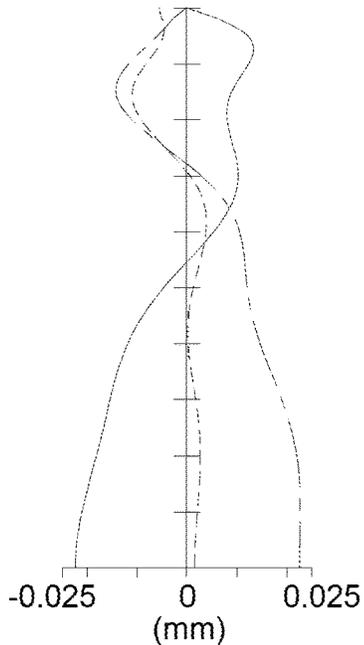


FIG. 43A

Field curvature (sagittal direction) image height (mm) 6.700

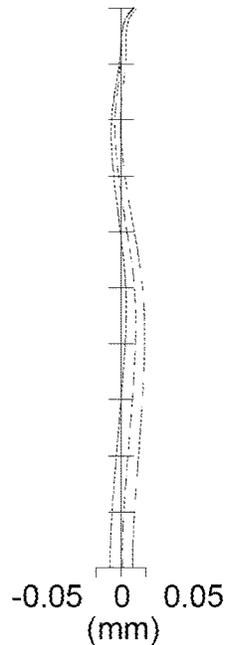
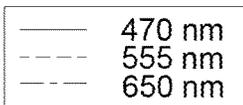


FIG. 43B



Field curvature (Tangential direction) image height (mm) 6.700

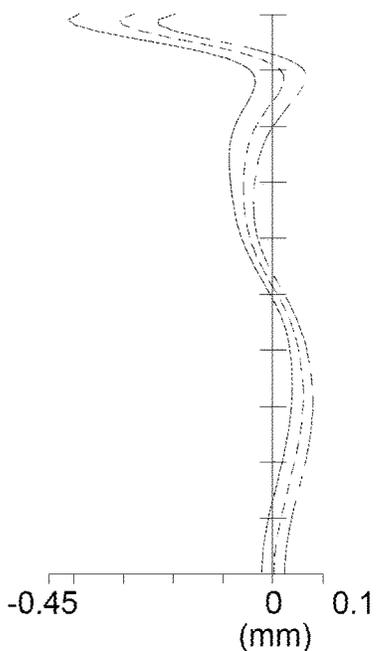


FIG. 43C

Distortion image height (mm) 6.700

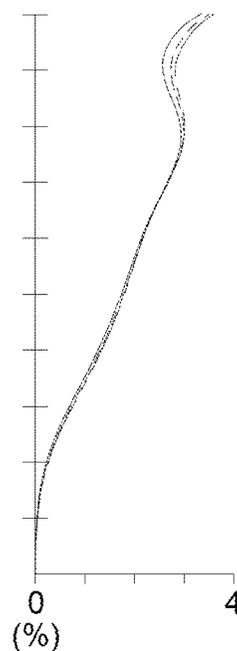


FIG. 43D

Embodiment 10							
EFL = 7.370 mm ; HFOV = 41.746 degrees ; TTL = 9.376 mm							
Fno = 2.102 ; Image Height = 6.700 mm							
Surface#		Radius of curvature (mm)	Thickness /air gap (mm)	Refractive index	Abbe number	Focal length (mm)	Material
OBJ	Object	INFINITY	INFINITY				
STO	Aperture stop	INFINITY	-0.462				
L1A1	1st lens element	3.031	0.965	1.545	55.987	6.891	Plastic
L1A2		13.804	0.242				
L2A1	2nd lens element	-12.951	0.378	1.661	20.373	-26.664	Plastic
L2A2		-48.182	0.660				
L3A1	3rd lens element	-23.008	0.472	1.545	55.987	-527193561.287	Plastic
L3A2		-23.175	0.016				
L4A1	4th lens element	9.966	0.864	1.661	20.373	-5000.657	Plastic
L4A2		9.591	0.842				
L5A1	5th lens element	-98.247	1.114	1.545	55.987	7.336	Plastic
L5A2		-3.866	0.022				
L6A1	6th lens element	14.119	0.622	1.661	20.373	-25.485	Plastic
L6A2		7.577	1.316				
L7A1	7th lens element	-5.833	0.788	1.640	23.529	-5.099	Plastic
L7A2		7.929	0.420				
TFA1	Filtering unit	INFINITY	0.210	1.517	64.167		
TFA2		INFINITY	0.118				
IMA	Image plane	INFINITY					

FIG. 44

Embodiment 10					
Aspherical Parameters					
Surface#	K	a4	a6	a8	a10
L1A1	-2.319815E-02	-7.284886E-05	3.547049E-04	-1.553083E-03	7.748258E-04
L1A2	0.000000E+00	-9.492842E-03	-1.879236E-03	4.824097E-04	-3.415819E-04
L2A1	0.000000E+00	-5.011510E-03	1.965852E-04	5.923895E-03	-3.438812E-03
L2A2	0.000000E+00	1.001085E-03	2.273843E-03	4.665855E-03	-2.591109E-03
L3A1	0.000000E+00	-5.964110E-03	-8.495561E-03	4.456303E-03	-1.695728E-03
L3A2	0.000000E+00	-2.113435E-02	3.592801E-03	1.551165E-03	-2.116905E-03
L4A1	3.048044E-02	-2.764291E-02	1.313900E-02	-4.965847E-03	1.068297E-03
L4A2	0.000000E+00	-8.983697E-03	-5.495623E-04	8.630617E-04	-4.331578E-04
L5A1	0.000000E+00	-7.573725E-03	5.883246E-03	-1.791764E-03	1.555038E-04
L5A2	-5.884832E-01	1.438464E-02	7.730634E-04	-8.940038E-04	1.803179E-04
L6A1	0.000000E+00	2.009525E-02	-7.602669E-03	6.270807E-04	8.578094E-05
L6A2	0.000000E+00	1.607892E-02	-8.980000E-03	1.617726E-03	-1.718271E-04
L7A1	3.380399E-02	7.765850E-03	-5.730101E-03	1.108000E-03	-1.051701E-04
L7A2	-3.360245E+00	-4.848213E-03	-1.296301E-03	2.726652E-04	-2.505421E-05
Surface#	a12	a14	a16	a18	a20
L1A1	-1.611942E-04	-1.859421E-05	5.579114E-06	\	\
L1A2	1.744487E-04	-4.269886E-05	4.024356E-06		
L2A1	1.017523E-03	-1.275882E-04	4.547997E-06		
L2A2	7.192104E-04	-1.013785E-04	1.015245E-05		
L3A1	3.904071E-04	-5.699743E-05	8.341492E-06		
L3A2	7.899008E-04	-1.364464E-04	1.071067E-05		
L4A1	-1.316923E-04	8.984752E-06	-2.892095E-07		
L4A2	1.359811E-04	-2.769863E-05	3.462919E-06	-2.352941E-07	6.541802E-09
L5A1	2.595349E-05	-8.211165E-06	8.993518E-07	-4.576207E-08	8.883180E-10
L5A2	-2.326467E-05	2.376978E-06	-1.706710E-07	6.906951E-09	-1.135850E-10
L6A1	-2.758308E-05	2.942991E-06	-1.495065E-07	3.251603E-09	-1.340400E-11
L6A2	1.099515E-05	-3.863512E-07	5.145562E-09	6.396400E-11	-1.906000E-12
L7A1	5.896294E-06	-2.055429E-07	4.399130E-09	-5.316400E-11	2.780000E-13
L7A2	1.380152E-06	-4.868994E-08	1.077349E-09	-1.355400E-11	7.300000E-14

FIG. 45

Embodiment	1st	2nd	3rd	4th	5th
T1	1.242	0.966	1.138	1.083	1.093
G12	0.106	0.210	0.105	0.133	0.130
T2	0.473	0.388	0.477	0.394	0.379
G23	0.655	0.597	0.812	0.587	0.789
T3	0.394	0.396	0.559	0.387	0.404
G34	0.032	0.079	0.013	0.054	0.043
T4	1.045	1.113	0.831	1.093	0.778
G45	1.041	1.017	0.962	1.009	0.926
T5	0.929	0.840	0.949	0.744	0.951
G56	0.013	0.102	0.184	0.094	0.185
T6	0.576	0.603	0.621	0.621	0.580
G67	1.124	1.124	0.850	1.127	1.128
T7	0.637	0.657	0.621	0.928	0.670
G7F	0.650	0.650	0.650	0.650	0.450
TTF	0.210	0.210	0.210	0.210	0.210
GFP	0.249	0.196	0.153	0.179	0.263
BFL	1.109	1.056	1.013	1.039	0.923
EFL	7.370	7.286	7.175	7.507	7.033
TTL	9.376	9.146	9.136	9.294	8.978
TL	8.267	8.091	8.123	8.255	8.054
ALT	5.296	4.961	5.196	5.250	4.854
AAG	2.971	3.129	2.927	3.005	3.200
ImgH	6.700	6.700	6.700	6.700	6.700
(T4+G45)/(T5+G56)	2.215	2.263	1.583	2.508	1.500
(ImgH+T4+G45)/(T5+G56)	9.329	9.380	7.496	10.504	7.400
(T1+G23)/(T3+G34)	4.453	3.295	3.412	3.781	4.219
(T5+T6+BFL)/(G56+G67)	2.300	2.037	2.498	1.968	1.869
(G45+T5)/(T2+G34)	3.905	3.982	3.902	3.910	4.453
(V3+V4+V5)/V6	6.496	6.496	6.496	6.496	6.496
TL/(T5+T6+T7)	3.860	3.855	3.707	3.600	3.659
ALT/(T1+G23)	2.791	3.174	2.664	3.144	2.579
(T1+T4)/G45	2.196	2.044	2.046	2.155	2.020
TTL/(T1+G67)	3.963	4.376	4.596	4.206	4.042
EFL/(G12+T2+G23+T3)	4.525	4.580	3.673	5.000	4.134
(T2+T4)/T5	1.634	1.788	1.379	1.999	1.216
(T6+T7)/T3	3.076	3.180	2.223	3.999	3.098
(G12+T2+G23+T3)/G67	1.450	1.415	2.298	1.332	1.508
(T2+T3+T5)/T7	2.819	2.473	3.195	1.643	2.585
(G34+T4)/G23	1.643	1.995	1.039	1.953	1.039
ImgH/(T4+T6)	4.134	3.905	4.614	3.910	4.937
(G45+G56)/T4	1.009	1.005	1.379	1.010	1.429
ImgH/(T1+T2)	3.906	4.949	4.149	4.536	4.551

FIG. 46A

Embodiment	6th	7th	8th	9th	10th
T1	1.114	1.079	1.009	1.190	0.965
G12	0.119	0.150	0.194	0.113	0.242
T2	0.384	0.386	0.435	0.381	0.378
G23	0.657	0.751	0.531	0.657	0.660
T3	0.516	0.398	0.474	0.525	0.472
G34	0.074	0.040	0.039	0.045	0.016
T4	0.830	0.955	0.989	0.966	0.864
G45	1.002	1.034	0.928	1.226	0.842
T5	0.915	0.757	0.940	0.674	1.114
G56	0.028	0.240	0.062	0.031	0.022
T6	0.751	0.509	0.692	0.663	0.622
G67	0.855	1.294	1.007	1.143	1.316
T7	0.829	0.542	0.849	0.823	0.788
G7F	0.650	0.650	0.650	0.650	0.420
TTF	0.210	0.210	0.210	0.210	0.210
GFP	0.122	0.031	0.088	0.135	0.118
BFL	0.982	0.891	0.948	0.995	0.748
EFL	7.164	7.180	7.024	8.029	7.145
TTL	9.058	9.025	9.098	9.431	9.049
TL	8.075	8.134	8.150	8.437	8.301
ALT	5.341	4.626	5.388	5.223	5.202
AAG	2.735	3.508	2.762	3.214	3.098
ImgH	6.700	6.700	6.700	6.700	6.700
$(T4+G45)/(T5+G56)$	1.943	1.996	1.912	3.109	1.502
$(\text{ImgH}+T4+G45)/(T5+G56)$	9.049	8.717	8.596	12.610	7.401
$(T1+G23)/(T3+G34)$	3.000	4.175	3.000	3.246	3.336
$(T5+T6+BFL)/(G56+G67)$	3.000	1.407	2.412	1.986	1.857
$(G45+T5)/(T2+G34)$	4.183	4.205	3.936	4.462	4.965
$(V3+V4+V5)/V6$	6.496	4.512	6.496	5.588	6.496
$TL/(T5+T6+T7)$	3.235	4.500	3.285	3.905	3.289
$ALT/(T1+G23)$	3.016	2.528	3.499	2.827	3.201
$(T1+T4)/G45$	1.941	1.967	2.154	1.760	2.171
$TTL/(T1+G67)$	4.600	3.803	4.513	4.042	3.968
$EFL/(G12+T2+G23+T3)$	4.273	4.263	4.298	4.792	4.077
$(T2+T4)/T5$	1.327	1.771	1.515	1.999	1.115
$(T6+T7)/T3$	3.061	2.637	3.252	2.833	2.991
$(G12+T2+G23+T3)/G67$	1.960	1.302	1.622	1.466	1.332
$(T2+T3+T5)/T7$	2.190	2.846	2.179	1.920	2.493
$(G34+T4)/G23$	1.376	1.326	1.936	1.539	1.331
$\text{ImgH}/(T4+T6)$	4.236	4.577	3.984	4.111	4.509
$(G45+G56)/T4$	1.239	1.334	1.001	1.300	1.001
$\text{ImgH}/(T1+T2)$	4.472	4.572	4.641	4.264	4.988

FIG. 46B

OPTICAL IMAGING LENS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to P.R.C. Patent Application No. 202111490150.1 titled "Optical Imaging Lens," filed on Dec. 8, 2021, with the China National Intellectual Property Administration (CNIPA) of the People's Republic of China.

TECHNICAL FIELD

The present disclosure relates to optical imaging lenses, and particularly, optical imaging lenses having, in some embodiments, seven lens elements.

BACKGROUND

As optical imaging lenses keep evolving to meet various requirements, such as slim and compact appearance. For taking a photograph or video in a dim environment, small f-number (Fno) to increase luminous flux and great image height to adapt to a great image sensor accepting image light are two keys to design the optical imaging lenses. Accordingly, designing an optical imaging lens with a slim and compact appearance, small Fno, great image height and good imaging quality may be a goal in the industry.

SUMMARY

In light of aforesaid problems, the present disclosure provides for optical imaging lenses showing a slim and compact appearance, small Fno, great image height and good imaging quality.

In an example embodiment, an optical imaging lens may be used for shooting a video or picture in a mobile electronic device, such as cell phone, digital camera, tablet computer, personal digital assistant (PDA), etc. The optical imaging lens may comprise seven lens elements, hereinafter referred to as first, second, third, fourth, fifth, sixth and seventh lens elements and positioned sequentially from an object side to an image side along an optical axis. Each of the first, second, third, fourth, fifth, sixth and seventh lens elements may also have an object-side surface facing toward the object side and allowing imaging rays to pass through. Each of the first, second, third, fourth, fifth, sixth and seventh lens elements may also have an image-side surface facing toward the image side and allowing the imaging rays to pass through. Through configuration of convex/concave surface shape of the seven lens elements, the optical imaging lens may increase resolution and enlarge aperture stop and image height at the same time.

In the specification, parameters used here are defined as follows: a thickness of the first lens element along the optical axis is represented by T1, a distance from the image-side surface of the first lens element to the object-side surface of the second lens element along the optical axis, i.e. an air gap between the first lens element and the second lens element along the optical axis is represented by G12, a thickness of the second lens element along the optical axis is represented by T2, a distance from the image-side surface of the second lens element to the object-side surface of the third lens element along the optical axis, i.e. an air gap between the second lens element and the third lens element along the optical axis is represented by G23, a thickness of the third lens element along the optical axis is represented by T3, a

distance from the image-side surface of the third lens element to the object-side surface of the fourth lens element along the optical axis, i.e. an air gap between the third lens element and the fourth lens element along the optical axis is represented by G34, a thickness of the fourth lens element along the optical axis is represented by T4, a distance from the image-side surface of the fourth lens element to the object-side surface of the fifth lens element along the optical axis, i.e. an air gap between the fourth lens element and the fifth lens element along the optical axis is represented by G45, a thickness of the fifth lens element along the optical axis is represented by T5, a distance from the image-side surface of the fifth lens element to the object-side surface of the sixth lens element along the optical axis, i.e. an air gap between the fifth lens element and the sixth lens element along the optical axis is represented by G56, a thickness of the sixth lens element along the optical axis is represented by T6, a distance from the image-side surface of the sixth lens element to the object-side surface of the seventh lens element along the optical axis, i.e. an air gap between the sixth lens element and the seventh lens element along the optical axis is represented by G67, a thickness of the seventh lens element along the optical axis is represented by T7, an air gap between the seventh lens element and a filtering unit along the optical axis is represented by G7F, a thickness of the filtering unit along the optical axis is represented by TTF, an air gap between the filtering unit and an image plane along the optical axis is represented by GFP, a focal length of the first lens element is represented by f1, a focal length of the second lens element is represented by f2, a focal length of the third lens element is represented by f3, a focal length of the fourth lens element is represented by f4, a focal length of the fifth lens element is represented by f5, a focal length of the sixth lens element is represented by f6, a focal length of the seventh lens element is represented by f7, a refractive index of the first lens element is represented by n1, a refractive index of the second lens element is represented by n2, a refractive index of the third lens element is represented by n3, a refractive index of the fourth lens element is represented by n4, a refractive index of the fifth lens element is represented by n5, a refractive index of the sixth lens element is represented by n6, a refractive index of the seventh lens element is represented by n7, an Abbe number of the first lens element is represented by V1, an Abbe number of the second lens element is represented by V2, an Abbe number of the third lens element is represented by V3, an Abbe number of the fourth lens element is represented by V4, an Abbe number of the fifth lens element is represented by V5, an Abbe number of the sixth lens element is represented by V6, an Abbe number of the seventh lens element is represented by V7, a half field of view of the optical imaging lens is represented by HFOV, a f-number of the optical imaging lens is represented by Fno, an effective focal length of the optical imaging lens is represented by EFL, a distance from the object-side surface of the first lens element to the image plane along the optical axis, i.e. a system length is represented by TTL, a sum of the thicknesses of all seven lens elements along the optical axis, i.e. a sum of T1, T2, T3, T4, T5, T6 and T7 is represented by ALT, a sum of a distance from the image-side surface of the first lens element to the object-side surface of the second lens element along the optical axis, a distance from the image-side surface of the second lens element to the object-side surface of the third lens element along the optical axis, a distance from the image-side surface of the third lens element to the object-side surface of the fourth lens element along the optical axis, a distance from the image-side surface of the fourth lens element to the object-side surface of the fifth lens element along the optical axis, a distance from the image-side surface of the fifth lens element to the object-side surface of the sixth lens element along the optical axis, a distance from the image-side surface of the sixth lens element to the object-side surface of the seventh lens element along the optical axis, a distance from the image-side surface of the seventh lens element to the object-side surface of the image plane along the optical axis, a distance from the object-side surface of the first lens element to the object-side surface of the image plane along the optical axis, a distance from the object-side surface of the second lens element to the object-side surface of the image plane along the optical axis, a distance from the object-side surface of the third lens element to the object-side surface of the image plane along the optical axis, a distance from the object-side surface of the fourth lens element to the object-side surface of the image plane along the optical axis, a distance from the object-side surface of the fifth lens element to the object-side surface of the image plane along the optical axis, a distance from the object-side surface of the sixth lens element to the object-side surface of the image plane along the optical axis, a distance from the object-side surface of the seventh lens element to the object-side surface of the image plane along the optical axis.

of the fourth lens element to the object-side surface of the fifth lens element along the optical axis, a distance from the image-side surface of the fifth lens element to the object-side surface of the sixth lens element along the optical axis and a distance from the image-side surface of the sixth lens element to the object-side surface of the seventh lens element along the optical axis, i.e. a sum of G12, G23, G34, G45, G56 and G67 is represented by AAG, a back focal length of the optical imaging lens, which is defined as the distance from the image-side surface of the seventh lens element to the image plane along the optical axis, i.e. a sum of G7F, TTF and GFP is represented by BFL, a distance from the object-side surface of the first lens element to the image-side surface of the seventh lens element along the optical axis is represented by TL, and an image height of the optical imaging lens is represented by ImgH.

In an aspect of the present disclosure, in the optical imaging lens, the second lens element has negative refracting power, the third lens element has negative refracting power, and an optical axis region of the object-side surface of the third lens element is concave, an optical axis region of the object-side surface of the fifth lens element is concave, and a periphery region of the image-side surface of the fifth lens element is convex, the sixth lens element has negative refracting power, and an optical axis region of the image-side surface of the sixth lens element is concave, lens elements of the optical imaging lens are only the seven lens elements, and the optical imaging lens satisfies:

$$(T4+G45)/(T5+G56) \geq 1.500 \quad \text{Inequality (1).}$$

In another aspect of the present disclosure, in the optical imaging lens, an optical axis region of the image-side surface of the first lens element is concave, the second lens element has negative refracting power, the third lens element has negative refracting power, and an optical axis region of the object-side surface of the third lens element is concave, an optical axis region of the object-side surface of the fifth lens element is concave, and a periphery region of the image-side surface of the fifth lens element is convex, the sixth lens element has negative refracting power, an optical axis region of the image-side surface of the seventh lens element is concave, lens elements of the optical imaging lens are only the seven lens elements, and the optical imaging lens satisfies:

$$(ImgH+T4+G45)/(T5+G56) \geq 7.400 \quad \text{Inequality (2).}$$

In yet another aspect of the present disclosure, in the optical imaging lens, an optical axis region of the image-side surface of the first lens element is concave, the second lens element has negative refracting power, the third lens element has negative refracting power, and an optical axis region of the object-side surface of the third lens element is concave, an optical axis region of the object-side surface of the fifth lens element is concave, the sixth lens element has negative refracting power, and a periphery region of the image-side surface of the sixth lens element is convex, an optical axis region of the image-side surface of the seventh lens element is concave, lens elements of the optical imaging lens are only the seven lens elements, and the optical imaging lens satisfies Inequality (2).

In another example embodiment, other inequality(s), such as those relating to the ratio among parameters could be taken into consideration. For example:

$$ImgH/(T4+T6) \geq 3.900 \quad \text{Inequality (3);}$$

$$ImgH/(T1+T2) \geq 3.900 \quad \text{Inequality (4);}$$

$$(T1+G23)/(T3+G34) \geq 3.000 \quad \text{Inequality (5);}$$

$$(T5+T6+BFL)/(G56+G67) \geq 3.000 \quad \text{Inequality (6);}$$

$$(G45+T5)/(T2+G34) \geq 3.900 \quad \text{Inequality (7);}$$

$$(F3+F4+F5)/F6 \geq 4.500 \quad \text{Inequality (8);}$$

$$TL/(T5+T6+T7) \geq 4.500 \quad \text{Inequality (9);}$$

$$ALT/(T1+G23) \leq 3.500 \quad \text{Inequality (10);}$$

$$(T1+T4)/G45 \leq 2.200 \quad \text{Inequality (11);}$$

$$TTL/(T1+G67) \leq 4.600 \quad \text{Inequality (12);}$$

$$EFL/(G12+T2+G23+T3) \leq 5.000 \quad \text{Inequality (13);}$$

$$(T2+T4)/T5 \leq 2.000 \quad \text{Inequality (14);}$$

$$(T6+T7)/T3 \leq 4.000 \quad \text{Inequality (15);}$$

$$(G12+T2+G23+T3)/G67 \leq 2.300 \quad \text{Inequality (16);}$$

$$(T2+T3+T5)/T7 \leq 3.200 \quad \text{Inequality (17);}$$

$$(G34+T4)/G23 \leq 2.000 \quad \text{Inequality (18); and/or}$$

$$(G45+G56)/T4 \geq 1.000 \quad \text{Inequality (19).}$$

In some example embodiments, more details about the convex or concave surface structure, refracting power or chosen material etc. could be incorporated for one specific lens element or broadly for a plurality of lens elements to improve the control for the system performance and/or resolution. It is noted that the details listed herein could be incorporated in example embodiments if no inconsistency occurs.

It is readily understood that through controlling the convex or concave shape of the surfaces, the optical imaging lens of the present invention may provide for a slim and compact appearance, small Fno, great image height and good imaging quality.

BRIEF DESCRIPTION OF THE DRAWINGS

Example embodiments will be more readily understood from the following detailed description when read in conjunction with the appended drawing, in which:

FIG. 1 depicts a cross-sectional view of one single lens element according to the present disclosure;

FIG. 2 depicts a cross-sectional view showing the relation between the shape of a portion and the position where a collimated ray meets the optical axis;

FIG. 3 depicts a cross-sectional view showing a first example of determining the shape of lens element regions and the boundaries of regions;

FIG. 4 depicts a cross-sectional view showing a second example of determining the shape of lens element regions and the boundaries of regions;

FIG. 5 depicts a cross-sectional view showing a third example of determining the shape of lens element regions and the boundaries of regions;

FIG. 6 depicts a cross-sectional view of a first embodiment of an optical imaging lens having seven lens elements according to the present disclosure;

FIGS. 7A-7D depict charts of a longitudinal spherical aberration and other kinds of optical aberrations of a first embodiment of the optical imaging lens according to the present disclosure;

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FIG. 8 depicts a table of optical data for each lens element of a first embodiment of an optical imaging lens according to the present disclosure;

FIG. 9 depicts a table of aspherical data of a first embodiment of the optical imaging lens according to the present disclosure;

FIG. 10 depicts a cross-sectional view of a second embodiment of an optical imaging lens having seven lens elements according to the present disclosure;

FIGS. 11A-11D depict charts of a longitudinal spherical aberration and other kinds of optical aberrations of a second embodiment of the optical imaging lens according to the present disclosure;

FIG. 12 depicts a table of optical data for each lens element of the optical imaging lens of a second embodiment of the present disclosure;

FIG. 13 depicts a table of aspherical data of a second embodiment of the optical imaging lens according to the present disclosure;

FIG. 14 depicts a cross-sectional view of a third embodiment of an optical imaging lens having seven lens elements according to the present disclosure;

FIGS. 15A-15D depict chart of a longitudinal spherical aberration and other kinds of optical aberrations of a third embodiment of the optical imaging lens according to the present disclosure;

FIG. 16 depicts a table of optical data for each lens element of the optical imaging lens of a third embodiment of the present disclosure;

FIG. 17 depicts a table of aspherical data of a third embodiment of the optical imaging lens according to the present disclosure;

FIG. 18 depicts a cross-sectional view of a fourth embodiment of an optical imaging lens having seven lens elements according to the present disclosure;

FIGS. 19A-19D depict charts of a longitudinal spherical aberration and other kinds of optical aberrations of a fourth embodiment of the optical imaging lens according to the present disclosure;

FIG. 20 depicts a table of optical data for each lens element of the optical imaging lens of a fourth embodiment of the present disclosure;

FIG. 21 depicts a table of aspherical data of a fourth embodiment of the optical imaging lens according to the present disclosure;

FIG. 22 depicts a cross-sectional view of a fifth embodiment of an optical imaging lens having seven lens elements according to the present disclosure;

FIGS. 23A-23D depict charts of a longitudinal spherical aberration and other kinds of optical aberrations of a fifth embodiment of the optical imaging lens according to the present disclosure;

FIG. 24 depicts a table of optical data for each lens element of the optical imaging lens of a fifth embodiment of the present disclosure;

FIG. 25 depicts a table of aspherical data of a fifth embodiment of the optical imaging lens according to the present disclosure;

FIG. 26 depicts a cross-sectional view of a sixth embodiment of an optical imaging lens having seven lens elements according to the present disclosure;

FIGS. 27A-27D depict charts of a longitudinal spherical aberration and other kinds of optical aberrations of a sixth embodiment of the optical imaging lens according to the present disclosure;

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FIG. 28 depicts a table of optical data for each lens element of the optical imaging lens of a sixth embodiment of the present disclosure;

FIG. 29 depicts a table of aspherical data of a sixth embodiment of the optical imaging lens according to the present disclosure;

FIG. 30 depicts a cross-sectional view of a seventh embodiment of an optical imaging lens having seven lens elements according to the present disclosure;

FIGS. 31A-31D depict charts of a longitudinal spherical aberration and other kinds of optical aberrations of a seventh embodiment of the optical imaging lens according to the present disclosure;

FIG. 32 depicts a table of optical data for each lens element of a seventh embodiment of an optical imaging lens according to the present disclosure;

FIG. 33 depicts a table of aspherical data of a seventh embodiment of the optical imaging lens according to the present disclosure;

FIG. 34 depicts a cross-sectional view of an eighth embodiment of an optical imaging lens having seven lens elements according to the present disclosure;

FIGS. 35A-35D depict charts of a longitudinal spherical aberration and other kinds of optical aberrations of an eighth embodiment of the optical imaging lens according to the present disclosure;

FIG. 36 depicts a table of optical data for each lens element of an eighth embodiment of an optical imaging lens according to the present disclosure;

FIG. 37 depicts a table of aspherical data of an eighth embodiment of the optical imaging lens according to the present disclosure;

FIG. 38 depicts a cross-sectional view of a ninth embodiment of an optical imaging lens having seven lens elements according to the present disclosure;

FIGS. 39A-39D depict charts of a longitudinal spherical aberration and other kinds of optical aberrations of a ninth embodiment of the optical imaging lens according to the present disclosure;

FIG. 40 depicts a table of optical data for each lens element of a ninth embodiment of an optical imaging lens according to the present disclosure;

FIG. 41 depicts a table of aspherical data of a ninth embodiment of the optical imaging lens according to the present disclosure;

FIG. 42 depicts a cross-sectional view of a tenth embodiment of an optical imaging lens having seven lens elements according to the present disclosure;

FIGS. 43A-43D depict charts of a longitudinal spherical aberration and other kinds of optical aberrations of a tenth embodiment of the optical imaging lens according to the present disclosure;

FIG. 44 depicts a table of optical data for each lens element of a tenth embodiment of an optical imaging lens according to the present disclosure;

FIG. 45 depicts a table of aspherical data of a tenth embodiment of the optical imaging lens according to the present disclosure;

FIGS. 46A and 46B depict tables for the values of $(T4+G45)/(T5+G56)$, $(\text{ImgH}+T4+G45)/(T5+G56)$, $(T1+G23)/(T3+G34)$, $(T5+T6+BFL)/(G56+G67)$, $(G45+T5)/(T2+G34)$, $(V3+V4+V5)/V6$, $TL/(T5+T6+T7)$, $ALT/(T1+G23)$, $(T1+T4)/G45$, $TTL/(T1+G67)$, $EFL/(G12+T2+G23+T3)$, $(T2+T4)/T5$, $(T6+T7)/T3$, $(G12+T2+G23+T3)/G67$, $(T2+T3+T5)/T7$, $(G34+T4)/G23$, $\text{ImgH}/(T4+T6)$, $(G45+G56)/T4$ and $\text{ImgH}/(T1+T2)$ of all ten example embodiments.

DETAILED DESCRIPTION

For a more complete understanding of the present disclosure and its advantages, reference is now made to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features. Persons of ordinary skill in the art having the benefit of the present disclosure will understand other variations for implementing embodiments within the scope of the present disclosure, including those specific examples described herein. The drawings are not limited to specific scale and similar reference numbers are used for representing similar elements. As used in the disclosures and the appended claims, the terms “example embodiment,” “exemplary embodiment,” and “present embodiment” do not necessarily refer to a single embodiment, although it may, and various example embodiments may be readily combined and interchanged, without departing from the scope or spirit of the present disclosure. Furthermore, the terminology as used herein is for the purpose of describing example embodiments only and is not intended to be a limitation of the disclosure. In this respect, as used herein, the term “in” may include “in” and “on”, and the terms “a”, “an” and “the” may include singular and plural references. Furthermore, as used herein, the term “by” may also mean “from”, depending on the context. Furthermore, as used herein, the term “if” may also mean “when” or “upon”, depending on the context. Furthermore, as used herein, the words “and/or” may refer to and encompass any and all possible combinations of one or more of the associated listed items.

The terms “optical axis region”, “periphery region”, “concave”, and “convex” used in this specification and claims should be interpreted based on the definition listed in the specification by the principle of lexicographer.

In the present disclosure, the optical system may comprise at least one lens element to receive imaging rays that are incident on the optical system over a set of angles ranging from parallel to an optical axis to a half field of view (HFOV) angle with respect to the optical axis. The imaging rays pass through the optical system to produce an image on an image plane. The term “a lens element having positive refracting power (or negative refracting power)” means that the paraxial refracting power of the lens element in Gaussian optics is positive (or negative). The term “an object-side (or image-side) surface of a lens element” refers to a specific region of that surface of the lens element at which imaging rays can pass through that specific region. Imaging rays include at least two types of rays: a chief ray L_c and a marginal ray L_m (as shown in FIG. 1). An object-side (or image-side) surface of a lens element can be characterized as having several regions, including an optical axis region, a periphery region, and, in some cases, one or more intermediate regions, as discussed more fully below.

FIG. 1 is a radial cross-sectional view of a lens element **100**. Two referential points for the surfaces of the lens element **100** can be defined: a central point, and a transition point. The central point of a surface of a lens element is a point of intersection of that surface and the optical axis I. As illustrated in FIG. 1, a first central point CP1 may be present on the object-side surface **110** of lens element **100** and a second central point CP2 may be present on the image-side surface **120** of the lens element **100**. The transition point is a point on a surface of a lens element, at which the line tangent to that point is perpendicular to the optical axis I. The optical boundary OB of a surface of the lens element is defined as a point at which the radially outermost marginal ray L_m passing through the surface of the lens element

intersects the surface of the lens element. All transition points lie between the optical axis I and the optical boundary OB of the surface of the lens element. A surface of the lens element **100** may have no transition point or have at least one transition point. If multiple transition points are present on a single surface, then these transition points are sequentially named along the radial direction of the surface with reference numerals starting from the first transition point. For example, the first transition point, e.g., TP1, (closest to the optical axis I), the second transition point, e.g., TP2, (as shown in FIG. 4), and the Nth transition point (farthest from the optical axis I).

When a surface of the lens element has at least one transition point, the region of the surface of the lens element from the central point to the first transition point TP1 is defined as the optical axis region, which includes the central point. The region located radially outside of the farthest transition point (the Nth transition point) from the optical axis I to the optical boundary OB of the surface of the lens element is defined as the periphery region. In some embodiments, there may be intermediate regions present between the optical axis region and the periphery region, with the number of intermediate regions depending on the number of the transition points. When a surface of the lens element has no transition point, the optical axis region is defined as a region of 0%-50% of the distance between the optical axis I and the optical boundary OB of the surface of the lens element, and the periphery region is defined as a region of 50%-100% of the distance between the optical axis I and the optical boundary OB of the surface of the lens element.

The shape of a region is convex if a collimated ray being parallel to the optical axis I and passing through the region is bent toward the optical axis I such that the ray intersects the optical axis I on the image side A2 of the lens element. The shape of a region is concave if the extension line of a collimated ray being parallel to the optical axis I and passing through the region intersects the optical axis I on the object side A1 of the lens element.

Additionally, referring to FIG. 1, the lens element **100** may also have a mounting portion **130** extending radially outward from the optical boundary OB. The mounting portion **130** is typically used to physically secure the lens element to a corresponding element of the optical system (not shown). Imaging rays do not reach the mounting portion **130**. The structure and shape of the mounting portion **130** are only examples to explain the technologies, and should not be taken as limiting the scope of the present disclosure. The mounting portion **130** of the lens elements discussed below may be partially or completely omitted in the following drawings.

Referring to FIG. 2, optical axis region Z1 is defined between central point CP and first transition point TP1. Periphery region Z2 is defined between TP1 and the optical boundary OB of the surface of the lens element. Collimated ray **211** intersects the optical axis I on the image side A2 of lens element **200** after passing through optical axis region Z1, i.e., the focal point of collimated ray **211** after passing through optical axis region Z1 is on the image side A2 of the lens element **200** at point R in FIG. 2. Accordingly, since the ray itself intersects the optical axis I on the image side A2 of the lens element **200**, optical axis region Z1 is convex. On the contrary, collimated ray **212** diverges after passing through periphery region Z2. The extension line EL of collimated ray **212** after passing through periphery region Z2 intersects the optical axis I on the object side A1 of lens element **200**, i.e., the focal point of collimated ray **212** after passing through periphery region Z2 is on the object side A1

at point M in FIG. 2. Accordingly, since the extension line EL of the ray intersects the optical axis I on the object side A1 of the lens element 200, periphery region Z2 is concave. In the lens element 200 illustrated in FIG. 2, the first transition point TP1 is the border of the optical axis region and the periphery region, i.e., TP1 is the point at which the shape changes from convex to concave.

Alternatively, there is another way for a person having ordinary skill in the art to determine whether an optical axis region is convex or concave by referring to the sign of "Radius of curvature" (the "R" value), which is the paraxial radius of shape of a lens surface in the optical axis region. The R value is commonly used in conventional optical design software such as Zemax and CodeV. The R value usually appears in the lens data sheet in the software. For an object-side surface, a positive R value defines that the optical axis region of the object-side surface is convex, and a negative R value defines that the optical axis region of the object-side surface is concave. Conversely, for an image-side surface, a positive R value defines that the optical axis region of the image-side surface is concave, and a negative R value defines that the optical axis region of the image-side surface is convex. The result found by using this method should be consistent with the method utilizing intersection of the optical axis by rays/extension lines mentioned above, which determines surface shape by referring to whether the focal point of a collimated ray being parallel to the optical axis I is on the object-side or the image-side of a lens element. As used herein, the terms "a shape of a region is convex (concave)," "a region is convex (concave)," and "a convex-(concave-) region," can be used alternatively.

FIG. 3, FIG. 4 and FIG. 5 illustrate examples of determining the shape of lens element regions and the boundaries of regions under various circumstances, including the optical axis region, the periphery region, and intermediate regions as set forth in the present specification.

FIG. 3 is a radial cross-sectional view of a lens element 300. As illustrated in FIG. 3, only one transition point TP1 appears within the optical boundary OB of the image-side surface 320 of the lens element 300. Optical axis region Z1 and periphery region Z2 of the image-side surface 320 of lens element 300 are illustrated. The R value of the image-side surface 320 is positive (i.e., $R > 0$). Accordingly, the optical axis region Z1 is concave.

In general, the shape of each region demarcated by the transition point will have an opposite shape to the shape of the adjacent region(s). Accordingly, the transition point will define a transition in shape, changing from concave to convex at the transition point or changing from convex to concave. In FIG. 3, since the shape of the optical axis region Z1 is concave, the shape of the periphery region Z2 will be convex as the shape changes at the transition point TP1.

FIG. 4 is a radial cross-sectional view of a lens element 400. Referring to FIG. 4, a first transition point TP1 and a second transition point TP2 are present on the object-side surface 410 of lens element 400. The optical axis region Z1 of the object-side surface 410 is defined between the optical axis I and the first transition point TP1. The R value of the object-side surface 410 is positive (i.e., $R > 0$). Accordingly, the optical axis region Z1 is convex.

The periphery region Z2 of the object-side surface 410, which is also convex, is defined between the second transition point TP2 and the optical boundary OB of the object-side surface 410 of the lens element 400. Further, intermediate region Z3 of the object-side surface 410, which is concave, is defined between the first transition point TP1 and the second transition point TP2. Referring once again to

FIG. 4, the object-side surface 410 includes an optical axis region Z1 located between the optical axis I and the first transition point TP1, an intermediate region Z3 located between the first transition point TP1 and the second transition point TP2, and a periphery region Z2 located between the second transition point TP2 and the optical boundary OB of the object-side surface 410. Since the shape of the optical axis region Z1 is designed to be convex, the shape of the intermediate region Z3 is concave as the shape of the intermediate region Z3 changes at the first transition point TP1, and the shape of the periphery region Z2 is convex as the shape of the periphery region Z2 changes at the second transition point TP2.

FIG. 5 is a radial cross-sectional view of a lens element 500. Lens element 500 has no transition point on the object-side surface 510 of the lens element 500. For a surface of a lens element with no transition point, for example, the object-side surface 510 of the lens element 500, the optical axis region Z1 is defined as the region of 0%-50% of the distance between the optical axis I and the optical boundary OB of the surface of the lens element and the periphery region is defined as the region of 50%-100% of the distance between the optical axis I and the optical boundary OB of the surface of the lens element. Referring to lens element 500 illustrated in FIG. 5, the optical axis region Z1 of the object-side surface 510 is defined between the optical axis I and 50% of the distance between the optical axis I and the optical boundary OB. The R value of the object-side surface 510 is positive (i.e., $R > 0$). Accordingly, the optical axis region Z1 is convex. For the object-side surface 510 of the lens element 500, because there is no transition point, the periphery region Z2 of the object-side surface 510 is also convex. It should be noted that lens element 500 may have a mounting portion (not shown) extending radially outward from the periphery region Z2.

In the present disclosure, example embodiments of an optical imaging lens may comprise a first lens element, a second lens element, a third lens element, a fourth lens element, a fifth lens element, a sixth lens element and a seventh lens element. Each of the lens elements may comprise an object-side surface facing toward an object side allowing imaging rays to pass through and an image-side surface facing toward an image side allowing the imaging rays to pass through. These lens elements may be arranged sequentially from the object side to the image side along an optical axis, and example embodiments of lens elements of the optical imaging lens are only the seven lens elements. Through controlling the convex or concave shape of the surfaces, the optical imaging lens in example embodiments may provide for higher resolution along with enlarged aperture stop and image height.

Example embodiments of an optical imaging lens may be designed with configuration of refracting power and surface shapes, such as negative refracting power of the second lens element that may effectively adjust deflection angle of light passing the first lens element. When the optical imaging lens is further designed with negative refracting power of the third lens element, a concave optical axis region of the object-side surface of the third lens element, image height may be effectively increased. When the optical imaging lens is even further designed with a concave optical axis region of the object-side surface of the fifth lens element, a convex periphery region of the image-side surface of the fifth lens element, negative refracting power of the sixth lens element and a concave optical axis region of the image-side surface of the sixth lens element, longitudinal spherical aberration may be balanced and systematic aberration and distortion

may be effectively decreased. When the optical imaging lens satisfies $(T4+G45)/(T5+G56) \geq 1.500$, decreased volume and good production yield may be offered; preferably, the optical imaging lens may satisfy $1.500 \leq (T4+G45)/(T5+G56) \leq 3.200$. Additionally, When the optical imaging lens is even further designed with positive refracting power of the first lens element or negative refracting power of the seventh lens element, it may be beneficial to decrease f-number.

Example embodiments of an optical imaging lens may be designed with configuration of refracting power and surface shapes, such as negative refracting power of the second lens element that may effectively adjust deflection angle of light passing the first lens element. When the optical imaging lens is further designed with negative refracting power of the third lens element, a concave optical axis region of the object-side surface of the third lens element, image height may be effectively increased. When the optical imaging lens is even further designed with a concave optical axis region of the image-side surface of the first lens element, a concave optical axis region of the object-side surface of the fifth lens element, a convex periphery region of the image-side surface of the fifth lens element, negative refracting power of the sixth lens element and a concave optical axis region of the image-side surface of the seventh lens element, longitudinal spherical aberration may be balanced and systematic aberration and distortion may be effectively decreased. When the optical imaging lens satisfies $(\text{ImgH}+T4+G45)/(T5+G56) \geq 7.400$, decreased volume and good production yield as well as great image height may be offered; preferably, the optical imaging lens may satisfy $7.400 \leq (\text{ImgH}+T4+G45)/(T5+G56) \leq 12.700$. Additionally, When the optical imaging lens is even further designed with positive refracting power of the first lens element or negative refracting power of the seventh lens element, it may be beneficial to decrease f-number.

Example embodiments of an optical imaging lens may be designed with configuration of refracting power and surface shapes, such as negative refracting power of the second lens element that may effectively adjust deflection angle of light passing the first lens element. When the optical imaging lens is further designed with negative refracting power of the third lens element, a concave optical axis region of the object-side surface of the third lens element, image height may be effectively increased. When the optical imaging lens is even further designed with a concave optical axis region of the image-side surface of the first lens element, a concave optical axis region of the object-side surface of the fifth lens element, negative refracting power of the sixth lens element, a convex periphery region of the image-side surface of the sixth lens element and a concave optical axis region of the image-side surface of the seventh lens element, longitudinal spherical aberration may be balanced and systematic aberration and distortion may be effectively decreased. When the optical imaging lens satisfies $(\text{ImgH}+T4+G45)/(T5+G56) \geq 7.400$, decreased volume and good production yield as well as great image height may be offered; preferably, the optical imaging lens may satisfy $7.400 \leq (\text{ImgH}+T4+G45)/(T5+G56) \leq 12.700$. Additionally, When the optical imaging lens is even further designed with positive refracting power of the first lens element or negative refracting power of the seventh lens element, it may be beneficial to decrease f-number.

When the optical imaging lens is further designed with positive refracting power of at least one of the first lens element and the seventh lens element or negative refracting

power of at least one of the first lens element and the seventh lens element, it may be beneficial to decrease f-number and maintain good image quality.

When example embodiments of an optical imaging lens satisfy one of the two combinations list below, sensitivity of system may be reduced: (a) positive refracting power of the fourth lens element or negative refracting power of the seventh lens element; (b) positive refracting power of the fifth lens element or negative refracting power of the seventh lens element.

When example embodiments of an optical imaging lens satisfy $\text{ImgH}/(T4+T6) \geq 3.900$ or $\text{ImgH}/(T1+T2) \geq 3.900$, both image height and luminous flux may be effectively increased; preferably, the optical imaging lens may satisfy $3.900 \leq \text{ImgH}/(T4+T6) \leq 5.000$, $3.900 \leq \text{ImgH}/(T1+T2) \leq 5.200$.

When example embodiments of an optical imaging lens satisfy $(V3+V4+V5)/V6 \geq 4.500$ through choosing proper materials, chromatic aberration may be decreased and refracting angle of light may be controlled to obtain better image quality; preferably, the optical imaging lens may satisfy $4.500 \leq (V3+V4+V5)/V6 \leq 6.600$.

When the optical imaging lens satisfies at least one of the inequalities listed below in order to shorten system length to properly adjust air gap between lens elements or thickness of lens element, consider difficulty of production and ensure image quality, it may be properly configured:

$(T1+G23)/(T3+G34) \geq 3.000$, and preferably, the optical imaging lens may satisfy $3.000 \leq (T1+G23)/(T3+G34) \leq 4.500$;

$(T5+T6+BFL)/(G56+G67) \leq 3.000$, and preferably, the optical imaging lens may satisfy $1.300 \leq (T5+T6+BFL)/(G56+G67) \leq 3.000$;

$(G45+T5)/(T2+G34) \leq 3.900$, and preferably, the optical imaging lens may satisfy $3.900 \leq (G45+T5)/(T2+G34) \leq 5.000$;

$TL/(T5+T6+T7) \leq 4.500$, and preferably, the optical imaging lens may satisfy $3.100 \leq TL/(T5+T6+T7) \leq 4.500$;

$ALT/(T1+G23) \leq 3.500$, and preferably, the optical imaging lens may satisfy $2.400 \leq ALT/(T1+G23) \leq 3.500$;

$(T1+T4)/G45 \leq 2.200$, and preferably, the optical imaging lens may satisfy $1.500 \leq (T1+T4)/G45 \leq 2.200$;

$TTL/(T1+G67) \leq 4.600$, and preferably, the optical imaging lens may satisfy $3.700 \leq TTL/(T1+G67) \leq 4.600$;

$EFL/(G12+T2+G23+T3) \leq 5.000$, and preferably, the optical imaging lens may satisfy $3.500 \leq EFL/(G12+T2+G23+T3) \leq 5.000$;

$(T2+T4)/T5 \leq 2.000$, and preferably, the optical imaging lens may satisfy $1.000 \leq (T2+T4)/T5 \leq 2.000$;

$(T6+T7)/T3 \leq 4.000$, and preferably, the optical imaging lens may satisfy $2.100 \leq (T6+T7)/T3 \leq 4.000$;

$(G12+T2+G23+T3)/G67 \leq 2.300$, and preferably, the optical imaging lens may satisfy $1.200 \leq (G12+T2+G23+T3)/G67 \leq 2.300$;

$(T2+T3+T5)/T7 \leq 3.200$, and preferably, the optical imaging lens may satisfy $1.500 \leq (T2+T3+T5)/T7 \leq 3.200$;

$(G34+T4)/G23 \leq 2.000$, and preferably, the optical imaging lens may satisfy $0.900 \leq (G34+T4)/G23 \leq 2.000$;

$(G45+G56)/T4 \leq 1.000$, and preferably, the optical imaging lens may satisfy $1.000 \leq (G45+G56)/T4 \leq 1.600$.

In light of the unpredictability in an optical system, satisfying these inequalities listed above may result in shortening the system length of the optical imaging lens, lowering the f-number, enlarging the shot angle, promoting the imaging quality and/or increasing the yield in the assembly process in the present disclosure.

When implementing example embodiments, more details about the convex or concave surface or refracting power

could be incorporated for one specific lens element or broadly for a plurality of lens elements to improve the control for the system performance and/or resolution, or promote the yield. For example, in an example embodiment, each lens element may be made from all kinds of transparent material, such as glass, resin, etc. It is noted that the details listed here could be incorporated in example embodiments if no inconsistency occurs.

Several example embodiments and associated optical data will now be provided for illustrating example embodiments of an optical imaging lens with an enlarged field of view as well as good optical characteristics. Reference is now made to FIGS. 6-9. FIG. 6 illustrates an example cross-sectional view of an optical imaging lens **1** having seven lens elements of the optical imaging lens according to a first example embodiment. FIGS. 7A-7D show example charts of a longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **1** according to an example embodiment. FIG. 8 illustrates an example table of optical data of each lens element of the optical imaging lens **1** according to an example embodiment. FIG. 9 depicts an example table of aspherical data of the optical imaging lens **1** according to an example embodiment.

As shown in FIG. 6, the optical imaging lens **1** of the present embodiment may comprise, in the order from an object side A1 to an image side A2 along an optical axis, an aperture stop STO, a first lens element L1, a second lens element L2, a third lens element L3, a fourth lens element L4, a fifth lens element L5, a sixth lens element L6 and a seventh lens element L7. A filtering unit TF and an image plane IMA of an image sensor may be positioned at the image side A2 of the optical lens **1**. Each of the first, second, third, fourth, fifth, sixth and seventh lens elements L1, L2, L3, L4, L5, L6, L7 and the filtering unit TF may comprise an object-side surface L1A1/L2A1/L3A1/L4A1/L5A1/L6A1/L7A1/TFA1 facing toward the object side A1 and an image-side surface L1A2/L2A2/L3A2/L4A2/L5A2/L6A2/L7A2/TFA2 facing toward the image side A2. The filtering unit TF, positioned between the seventh lens element L7 and the image plane IMA, may selectively absorb light with specific wavelength(s) from the light passing through optical imaging lens **1**. The example embodiment of the filtering unit TF which may selectively absorb light with specific wavelength(s) from the light passing through optical imaging lens **1** may be an IR cut filter (infrared cut filter). Then, IR light may be absorbed, and this may prohibit the IR light, which might not be seen by human eyes, from producing an image on the image plane IMA.

Please refer to the drawings for the details of each lens element of the optical imaging lens **1**, which may be constructed by plastic material or other material for light weight.

In the first example embodiment, the first lens element L1 may have positive refracting power. On the object-side surface UAL both an optical axis region L1A1C and a periphery region L1A1P may be convex. On the image-side surface L1A2, both an optical axis region L1A2C and a periphery region L1A2P may be concave.

The second lens element L2 may have negative refracting power. On the object-side surface L2A1, both an optical axis region L2A1C and a periphery region L2A1P may be convex. On the image-side surface L2A2, both an optical axis region L2A2C and a periphery region L2A2P may be concave.

The third lens element L3 may have negative refracting power. On the object-side surface L3A1, both an optical axis region L3A1C and a periphery region L3A1P may be

concave. On the image-side surface L3A2, both an optical axis region L3A2C and a periphery region L3A2P may be convex.

The fourth lens element L4 may have positive refracting power. On the object-side surface L4A1, both an optical axis region L4A1C and a periphery region L4A1P may be convex. On the image-side surface L4A2, an optical axis region L4A2C may be concave, and a periphery region L4A2P may be convex.

The fifth lens element L5 may have positive refracting power. On the object-side surface L5A1, both an optical axis region L5A1C and a periphery region L5A1P may be concave. On the image-side surface L5A2, both an optical axis region L5A2C and a periphery region L5A2P may be convex.

The sixth lens element L6 may have negative refracting power. On the object-side surface L6A1, an optical axis region L6A1C may be convex and a periphery region L6A1P may be concave. On the image-side surface L6A2, an optical axis region L6A2C may be concave and a periphery region L6A2P may be convex.

The seventh lens element L7 may have negative refracting power. On the object-side surface L7A1, an optical axis region L7A1C may be concave and a periphery region L7A1P may be convex. On the image-side surface L7A2, an optical axis region L7A2C may be concave and a periphery region L7A2P may be convex.

A total of 14 aspherical surfaces, including the object-side surface L1A1 and the image-side surface L1A2 of the first lens element L1, the object-side surface L2A1 and the image-side surface L2A2 of the second lens element L2, the object-side surface L3A1 and the image-side surface L3A2 of the third lens element L3, the object-side surface L4A1 and the image-side surface L4A2 of the fourth lens element L4, the object-side surface L5A1 and the image-side surface L5A2 of the fifth lens element L5, the object-side surface L6A1 and the image-side surface L6A2 of the sixth lens element L6 and the object-side surface L7A1 and the image-side surface L7A2 of the seventh lens element L7 may all be defined by the following aspherical formula (1):

$$Z(Y) = \frac{Y^2}{R} \left(1 + \sqrt{1 - (1 + K) \frac{Y^2}{R^2}} \right) + \sum_{i=1}^n a_{2i} \times Y^{2i} \quad \text{Formula (1)}$$

wherein Z represents the depth of the aspherical surface (the perpendicular distance between the point of the aspherical surface at a distance Y from the optical axis and the tangent plane of the vertex on the optical axis of the aspherical surface); R represents the radius of curvature of the surface of the lens element; Y represents the perpendicular distance between the point of the aspherical surface and the optical axis; K represents a conic constant; a_{2i} represents an aspherical coefficient of $2i^{th}$ level.

The values of each aspherical parameter are shown in FIG. 9.

Referring to FIG. 7A, a longitudinal spherical aberration of three representative wavelengths (470 nm, 555 nm, 650 nm) of the optical imaging lens **1** in the present embodiment is shown in coordinates in which a vertical axis represents field of view, and FIG. 7B, curvature of field of three representative wavelengths (470 nm, 555 nm, 650 nm) of the optical imaging lens **1** in the present embodiment in the sagittal direction is shown in coordinates in which a vertical axis represents image height, and FIG. 7C, curvature of field in the tangential direction of three representative wave-

lengths (470 nm, 555 nm, 650 nm) of the optical imaging lens 1 in the present embodiment is shown in coordinates in which a vertical axis represents image height, and FIG. 7D, distortion aberration of the optical imaging lens 1 in the present embodiment is shown in coordinates in which a vertical axis represents image height. The curve of each of these wavelengths may be close to each other, and this represents that off-axis light with respect to the three representative wavelengths (470 nm, 555 nm, 650 nm) may be focused around an image point. From the vertical deviation of each curve shown in FIG. 7A, the offset of the off-axis light relative to the image point may be within about $-0.02\sim-0.025$ mm. Therefore, the present embodiment improves the longitudinal spherical aberration with respect to different wavelengths certainly. Further, for curvature of field in the sagittal direction shown in FIG. 7B, the focus variation with respect to the three wavelengths in the whole field may fall within about $-0.03\sim-0.04$ mm. For curvature of field in the tangential direction shown in FIG. 7C, the focus variation with respect to the three wavelengths in the whole field may fall within about $-0.08\sim-0.07$ mm. The variation of the distortion aberration shown in FIG. 7D may be within about 0~3%.

As shown in FIG. 8, the Fno the optical imaging lens 1 is 2.100, and the image height is 6.700 mm. Referring to the aberration shown in FIGS. 7A-7D, it may be readily understood that the optical imaging lens 1 is capable to provide with enlarged aperture stop and image height, as well as good optical characteristics.

Please also refer to FIG. 46A for the values of each parameter and $(T4+G45)/(T5+G56)$, $(\text{ImgH}+T4+G45)/(T5+G56)$, $(T1+G23)/(T3+G34)$, $(T5+T6+BFL)/(G56+G67)$, $(G45+T5)/(T2+G34)$, $(V3+V4+V5)/V6$, $TL/(T5+T6+T7)$, $ALT/(T1+G23)$, $(T1+T4)/G45$, $TTL/(T1+G67)$, $EFL/(G12+T2+G23+T3)$, $(T2+T4)/T5$, $(T6+T7)/T3$, $(G12+T2+G23+T3)/G67$, $(T2+T3+T5)/T7$, $(G34+T4)/G23$, $\text{ImgH}/(T4+T6)$, $(G45+G56)/T4$ and $\text{ImgH}/(T1+T2)$ of the present embodiment.

Reference is now made to FIGS. 10-13. FIG. 10 illustrates an example cross-sectional view of an optical imaging lens 2 having seven lens elements of the optical imaging lens according to a second example embodiment. FIGS. 11A, 11B, 11C and 11D show example charts of a longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens 2 according to the second example embodiment. FIG. 12 shows an example table of optical data of each lens element of the optical imaging lens 2 according to the second example embodiment. FIG. 13 shows an example table of aspherical data of the optical imaging lens 2 according to the second example embodiment.

As shown in FIG. 10, the optical imaging lens 2 of the present embodiment, in an order from an object side A1 to an image side A2 along an optical axis, may comprise an aperture stop STO, a first lens element L1, a second lens element L2, a third lens element L3, a fourth lens element L4, a fifth lens element L5, a sixth lens element L6 and a seventh lens element L7.

The configuration of the concave/convex shape of surfaces, comprising the object-side surfaces L1A1, L2A1, L3A1, L4A1, L5A1, L6A1 and L7A1 and the image-side surfaces L2A2, L3A2, L4A2, L5A2, L6A2 and L7A2, and positive or negative configuration of the refracting power of each lens element may be similar to those in the first embodiment; however, the configuration of the concave/convex shape of the image-side surface L1A2 may be different from those in the first embodiment. Further, the radius of curvature and thickness of each lens element,

aspherical data and related optical parameters, such as effective focal length, may be different from those in the first embodiment. Specifically, a periphery region L1A2P on the image-side surface L1A2 of the first lens element L1 may be convex.

Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment may be labeled. Please refer to FIG. 12 for the optical characteristics of each lens elements in the optical imaging lens 2 of the present embodiment.

As the longitudinal spherical aberration shown in FIG. 11A, the offset of the off-axis light relative to the image point may be within about $-0.015\sim-0.025$ mm. As the curvature of field in the sagittal direction shown in FIG. 11B, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.02\sim-0.04$ mm. As the curvature of field in the tangential direction shown in FIG. 11C, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.02\sim-0.12$ mm. As shown in FIG. 11D, the variation of the distortion aberration may be within about 0~2%. Compared with the first embodiment, the distortion aberration of the optical imaging lens 2 may be smaller.

As shown in FIG. 12, in the optical imaging lens 2, the Fno is 1.897 and the image height is 6.700 mm. Referring to the aberration shown in FIGS. 11A-11D, it may be readily understood that the optical imaging lens 2 is capable to provide with enlarged aperture stop and image height, as well as good imaging quality.

Please refer to FIG. 46A for the values of each parameter and $(T4+G45)/(T5+G56)$, $(\text{ImgH}+T4+G45)/(T5+G56)$, $(T1+G23)/(T3+G34)$, $(T5+T6+BFL)/(G56+G67)$, $(G45+T5)/(T2+G34)$, $(V3+V4+V5)/V6$, $TL/(T5+T6+T7)$, $ALT/(T1+G23)$, $(T1+T4)/G45$, $TTL/(T1+G67)$, $EFL/(G12+T2+G23+T3)$, $(T2+T4)/T5$, $(T6+T7)/T3$, $(G12+T2+G23+T3)/G67$, $(T2+T3+T5)/T7$, $(G34+T4)/G23$, $\text{ImgH}/(T4+T6)$, $(G45+G56)/T4$ and $\text{ImgH}/(T1+T2)$ of the present embodiment.

Reference is now made to FIGS. 14-17. FIG. 14 illustrates an example cross-sectional view of an optical imaging lens 3 having seven lens elements of the optical imaging lens according to a third example embodiment. FIGS. 15A, 15B, 15C and 15D show example charts of a longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens 3 according to the third example embodiment. FIG. 16 shows an example table of optical data of each lens element of the optical imaging lens 3 according to the third example embodiment. FIG. 17 shows an example table of aspherical data of the optical imaging lens 3 according to the third example embodiment.

As shown in FIG. 14, the optical imaging lens 3 of the present embodiment, in an order from an object side A1 to an image side A2 along an optical axis, may comprise an aperture stop STO, a first lens element L1, a second lens element L2, a third lens element L3, a fourth lens element L4, a fifth lens element L5, a sixth lens element L6 and a seventh lens element L7.

The configuration of the concave/convex shape of surfaces, comprising the object-side surfaces L1A1, L2A1, L3A1, L4A1, L5A1, L6A1 and L7A1 and the image-side surfaces L2A2, L3A2, L5A2, L6A2 and L7A2, and positive or negative configuration of the refracting power of each lens element may be similar to those in the first embodiment; however, the configuration of the concave/convex shape of the image-side surfaces L1A2, L4A2 may be different from those in the first embodiment. Further, the radius of curva-

ture and thickness of each lens element, aspherical data and related optical parameters, such as effective focal length, may be different from those in the first embodiment. Specifically, a periphery region L1A2P on the image-side surface L1A2 of the first lens element L1 may be convex, and a periphery region L4A2P on the image-side surface L4A2 of the fourth lens element L4 may be concave.

Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment may be labeled. Please refer to FIG. 16 for the optical characteristics of each lens elements in the optical imaging lens 3 of the present embodiment.

As the longitudinal spherical aberration shown in FIG. 15A, the offset of the off-axis light relative to the image point may be within about $-0.02\sim-0.018$ mm. As the curvature of field in the sagittal direction shown in FIG. 15B, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.02\sim-0.04$ mm. As the curvature of field in the tangential direction shown in FIG. 15C, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.14\sim-0.08$ mm. As shown in FIG. 15D, the variation of the distortion aberration may be within about $0\sim2\%$. Compared with the first embodiment, the longitudinal spherical aberration, the curvature of field in the sagittal direction and the distortion aberration may be smaller in the present embodiment.

As shown in FIG. 16, in the optical imaging lens 3, the Fno is 2.300 and the image height is 6.700 mm. Referring to the aberration shown in FIGS. 15A-15D, it may be readily understood that the optical imaging lens 3 is capable to provide with enlarged aperture stop and image height, as well as good imaging quality.

Please refer to FIG. 46A for the values of each parameter and $(T4+G45)/(T5+G56)$, $(\text{ImgH}+T4+G45)/(T5+G56)$, $(T1+G23)/(T3+G34)$, $(T5+T6+BFL)/(G56+G67)$, $(G45+T5)/(T2+G34)$, $(V3+V4+V5)/V6$, $TL/(T5+T6+T7)$, $ALT/(T1+G23)$, $(T1+T4)/G45$, $TTL/(T1+G67)$, $EFL/(G12+T2+G23+T3)$, $(T2+T4)/T5$, $(T6+T7)/T3$, $(G12+T2+G23+T3)/G67$, $(T2+T3+T5)/T7$, $(G34+T4)/G23$, $\text{ImgH}/(T4+T6)$, $(G45+G56)/T4$ and $\text{ImgH}/(T1+T2)$ of the present embodiment.

Reference is now made to FIGS. 18-21. FIG. 18 illustrates an example cross-sectional view of an optical imaging lens 4 having seven lens elements of the optical imaging lens according to a fourth example embodiment. FIGS. 19A, 19B, 19C and 19D show example charts of a longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens 4 according to the fourth example embodiment. FIG. 20 shows an example table of optical data of each lens element of the optical imaging lens 4 according to the fourth example embodiment. FIG. 21 shows an example table of aspherical data of the optical imaging lens 4 according to the fourth example embodiment.

As shown in FIG. 18, the optical imaging lens 4 of the present embodiment, in an order from an object side A1 to an image side A2 along an optical axis, may comprise an aperture stop STO, a first lens element L1, a second lens element L2, a third lens element L3, a fourth lens element L4, a fifth lens element L5, a sixth lens element L6 and a seventh lens element L7.

The configuration of the concave/convex shape of surfaces, comprising the object-side surfaces L1A1, L2A1, L3A1, L5A1, L6A1 and L7A1 and the image-side surfaces L1A2, L2A2, L3A2, L4A2, L5A2, L6A2 and L7A2, and positive or negative configuration of the refracting power of each lens element may be similar to those in the first

embodiment; however, the configuration of the concave/convex shape of the object-side surface L4A1 may be different from those in the first embodiment. Further, the radius of curvature and thickness of each lens element, aspherical data and related optical parameters, such as effective focal length, may be different from those in the first embodiment. Specifically, a periphery region L4A1P on the object-side surface L4A1 of the fourth lens element L4 may be concave.

Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment may be labeled. Please refer to FIG. 20 for the optical characteristics of each lens elements in the optical imaging lens 4 of the present embodiment.

As the longitudinal spherical aberration shown in FIG. 19A, the offset of the off-axis light relative to the image point may be within about $-0.012\sim-0.016$ mm. As the curvature of field in the sagittal direction shown in FIG. 19B, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.015\sim-0.025$ mm. As the curvature of field in the tangential direction shown in FIG. 19C, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.02\sim-0.05$ mm. As shown in FIG. 19D, the variation of the distortion aberration may be within about $0\sim1.6\%$. Compared with the first embodiment, the longitudinal spherical aberration, the curvature of field in both the sagittal and the tangential directions and the distortion aberration may be smaller in the present embodiment.

As shown in FIG. 20, in the optical imaging lens 4, the Fno is 2.230 and the image height is 6.700 mm. Referring to the aberration shown in FIGS. 19A-19D, it may be readily understood that the optical imaging lens 4 is capable to provide with enlarged aperture stop and image height, as well as good imaging quality.

Please refer to FIG. 46A for the values of each parameter and $(T4+G45)/(T5+G56)$, $(\text{ImgH}+T4+G45)/(T5+G56)$, $(T1+G23)/(T3+G34)$, $(T5+T6+BFL)/(G56+G67)$, $(G45+T5)/(T2+G34)$, $(V3+V4+V5)/V6$, $TL/(T5+T6+T7)$, $ALT/(T1+G23)$, $(T1+T4)/G45$, $TTL/(T1+G67)$, $EFL/(G12+T2+G23+T3)$, $(T2+T4)/T5$, $(T6+T7)/T3$, $(G12+T2+G23+T3)/G67$, $(T2+T3+T5)/T7$, $(G34+T4)/G23$, $\text{ImgH}/(T4+T6)$, $(G45+G56)/T4$ and $\text{ImgH}/(T1+T2)$ of the present embodiment.

Reference is now made to FIGS. 22-25. FIG. 22 illustrates an example cross-sectional view of an optical imaging lens 5 having seven lens elements of the optical imaging lens according to a fifth example embodiment. FIGS. 23A, 23B, 23C and 23D show example charts of a longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens 5 according to the fifth example embodiment. FIG. 24 shows an example table of optical data of each lens element of the optical imaging lens 5 according to the fifth example embodiment. FIG. 25 shows an example table of aspherical data of the optical imaging lens 5 according to the fifth example embodiment.

As shown in FIG. 22, the optical imaging lens 5 of the present embodiment, in an order from an object side A1 to an image side A2 along an optical axis, may comprise an aperture stop STO, a first lens element L1, a second lens element L2, a third lens element L3, a fourth lens element L4, a fifth lens element L5, a sixth lens element L6 and a seventh lens element L7.

The configuration of the concave/convex shape of surfaces, comprising the object-side surfaces L1A1, L2A1, L3A1, L4A1, L5A1, L6A1 and L7A1 and the image-side

surfaces L1A2, L2A2, L3A2, L5A2, L6A2 and L7A2, and positive or negative configuration of the refracting power of each lens element may be similar to those in the first embodiment; however, the configuration of the concave/convex shape of the image-side surface L4A2 may be different from those in the first embodiment. Further, the radius of curvature and thickness of each lens element, aspherical data and related optical parameters, such as effective focal length, may be different from those in the first embodiment. Specifically, a periphery region L4A2P on the image-side surface L4A2 of the fourth lens element L4 may be concave.

Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment may be labeled. Please refer to FIG. 24 for the optical characteristics of each lens element in the optical imaging lens 5 of the present embodiment.

As the longitudinal spherical aberration shown in FIG. 23A, the offset of the off-axis light relative to the image point may be within about $-0.02\sim 0.025$ mm. As the curvature of field in the sagittal direction shown in FIG. 23B, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.04\sim 0.04$ mm. As the curvature of field in the tangential direction shown in FIG. 23C, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.06\sim 0.14$ mm. As shown in FIG. 23D, the variation of the distortion aberration may be within about 0~4%.

As shown in FIG. 24, in the optical imaging lens 5, the F_{no} is 1.700 and the image height is 6.700 mm. Referring to the aberration shown in FIGS. 23A-23D, it may be readily understood that the optical imaging lens 5 is capable to provide with enlarged aperture stop and image height, as well as good imaging quality.

Please refer to FIG. 46A for the values of each parameter and $(T4+G45)/(T5+G56)$, $(\text{ImgH}+T4+G45)/(T5+G56)$, $(T1+G23)/(T3+G34)$, $(T5+T6+BFL)/(G56+G67)$, $(G45+T5)/(T2+G34)$, $(V3+V4+V5)/V6$, $TL/(T5+T6+T7)$, $ALT/(T1+G23)$, $(T1+T4)/G45$, $TTL/(T1+G67)$, $EFL/(G12+T2+G23+T3)$, $(T2+T4)/T5$, $(T6+T7)/T3$, $(G12+T2+G23+T3)/G67$, $(T2+T3+T5)/T7$, $(G34+T4)/G23$, $\text{ImgH}/(T4+T6)$, $(G45+G56)/T4$ and $\text{ImgH}/(T1+T2)$ of the present embodiment.

Reference is now made to FIGS. 26-29. FIG. 26 illustrates an example cross-sectional view of an optical imaging lens 6 having seven lens elements of the optical imaging lens according to a sixth example embodiment. FIGS. 27A, 27B, 27C and 27D show example charts of a longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens 6 according to the sixth example embodiment. FIG. 28 shows an example table of optical data of each lens element of the optical imaging lens 6 according to the sixth example embodiment. FIG. 29 shows an example table of aspherical data of the optical imaging lens 6 according to the sixth example embodiment.

As shown in FIG. 26, the optical imaging lens 6 of the present embodiment, in an order from an object side A1 to an image side A2 along an optical axis, may comprise an aperture stop STO, a first lens element L1, a second lens element L2, a third lens element L3, a fourth lens element L4, a fifth lens element L5, a sixth lens element L6 and a seventh lens element L7.

The configuration of the concave/convex shape of surfaces, comprising the object-side surfaces L1A1, L2A1, L3A1, L4A1, L5A1, L6A1 and L7A1 and the image-side surfaces L1A2, L2A2, L3A2, L4A2, L5A2, L6A2 and

L7A2, and positive or negative configuration of the refracting power of each lens element may be similar to those in the first embodiment; however, the radius of curvature and thickness of each lens element, aspherical data and related optical parameters, such as effective focal length, may be different from those in the first embodiment.

Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment may be labeled. Please refer to FIG. 28 for the optical characteristics of each lens element in the optical imaging lens 6 of the present embodiment.

As the longitudinal spherical aberration shown in FIG. 27A, the offset of the off-axis light relative to the image point may be within about $-0.02\sim 0.025$ mm. As the curvature of field in the sagittal direction shown in FIG. 27B, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.02\sim 0.04$ mm. As the curvature of field in the tangential direction shown in FIG. 27C, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.04\sim 0.16$ mm. As shown in FIG. 27D, the variation of the distortion aberration may be within about 0~4%. Compared with the first embodiment, the curvature of field in the sagittal direction may be smaller in the present embodiment.

As shown in FIG. 28, in the optical imaging lens 6, the F_{no} is 1.703 and the image height is 6.700 mm. Referring to the aberration shown in FIGS. 27A-27D, it may be readily understood that the optical imaging lens 6 is capable to provide with enlarged aperture stop and image height, as well as good imaging quality.

Please refer to FIG. 46B for the values of each parameter and $(T4+G45)/(T5+G56)$, $(\text{ImgH}+T4+G45)/(T5+G56)$, $(T1+G23)/(T3+G34)$, $(T5+T6+BFL)/(G56+G67)$, $(G45+T5)/(T2+G34)$, $(V3+V4+V5)/V6$, $TL/(T5+T6+T7)$, $ALT/(T1+G23)$, $(T1+T4)/G45$, $TTL/(T1+G67)$, $EFL/(G12+T2+G23+T3)$, $(T2+T4)/T5$, $(T6+T7)/T3$, $(G12+T2+G23+T3)/G67$, $(T2+T3+T5)/T7$, $(G34+T4)/G23$, $\text{ImgH}/(T4+T6)$, $(G45+G56)/T4$ and $\text{ImgH}/(T1+T2)$ of the present embodiment.

Reference is now made to FIGS. 30-33. FIG. 30 illustrates an example cross-sectional view of an optical imaging lens 7 having seven lens elements of the optical imaging lens according to a seventh example embodiment. FIGS. 31A, 31B, 31C and 31D show example charts of a longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens 7 according to the seventh example embodiment. FIG. 32 shows an example table of optical data of each lens element of the optical imaging lens 7 according to the seventh example embodiment. FIG. 33 shows an example table of aspherical data of the optical imaging lens 7 according to the seventh example embodiment.

As shown in FIG. 30, the optical imaging lens 7 of the present embodiment, in an order from an object side A1 to an image side A2 along an optical axis, may comprise an aperture stop STO, a first lens element L1, a second lens element L2, a third lens element L3, a fourth lens element L4, a fifth lens element L5, a sixth lens element L6 and a seventh lens element L7.

The configuration of the concave/convex shape of surfaces, comprising the object-side surfaces L1A1, L2A1, L3A1, L4A1, L5A1, L6A1 and L7A1 and the image-side surfaces L1A2, L2A2, L3A2, L5A2, L6A2 and L7A2, and positive or negative configuration of the refracting power of each lens element may be similar to those in the first embodiment; however, the configuration of the concave/convex shape of the image-side surface L4A2 may be

different from those in the first embodiment. Further, the radius of curvature and thickness of each lens element, aspherical data and related optical parameters, such as effective focal length, may be different from those in the first embodiment. Specifically, an optical axis region L4A2C on the image-side surface L4A2 of the fourth lens element L4

may be convex. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment may be labeled. Please refer to FIG. 32 for the optical characteristics of each lens element in the optical imaging lens 7 of the present embodiment.

As the longitudinal spherical aberration shown in FIG. 31A, the offset of the off-axis light relative to the image point may be within about $-0.015\sim 0.025$ mm. As the curvature of field in the sagittal direction shown in FIG. 31B, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.02\sim 0.04$ mm. As the curvature of field in the tangential direction shown in FIG. 31C, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.04\sim 0.14$ mm. As shown in FIG. 31D, the variation of the distortion aberration may be within about $0\sim 4\%$. Compared with the first embodiment, the longitudinal spherical aberration and the curvature of field in the sagittal direction may be smaller in the present embodiment.

As shown in FIG. 32, in the optical imaging lens 7, the F_{no} is 1.705 and the image height is 6.700 mm. Referring to the aberration shown in FIGS. 31A-31D, it may be readily understood that the optical imaging lens 7 is capable to provide with enlarged aperture stop and image height, as well as good imaging quality.

Please refer to FIG. 46B for the values of each parameter and $(T4+G45)/(T5+G56)$, $(\text{ImgH}+T4+G45)/(T5+G56)$, $(T1+G23)/(T3+G34)$, $(T5+T6+BFL)/(G56+G67)$, $(G45+T5)/(T2+G34)$, $(V3+V4+V5)/V6$, $TL/(T5+T6+T7)$, $ALT/(T1+G23)$, $(T1+T4)/G45$, $TTL/(T1+G67)$, $EFL/(G12+T2+G23+T3)$, $(T2+T4)/T5$, $(T6+T7)/T3$, $(G12+T2+G23+T3)/G67$, $(T2+T3+T5)/T7$, $(G34+T4)/G23$, $\text{ImgH}/(T4+T6)$, $(G45+G56)/T4$ and $\text{ImgH}/(T1+T2)$ of the present embodiment.

Reference is now made to FIGS. 34-37. FIG. 34 illustrates an example cross-sectional view of an optical imaging lens 8 having seven lens elements of the optical imaging lens according to an eighth example embodiment. FIGS. 35A, 35B, 35C and 35D show example charts of a longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens 8 according to the eighth example embodiment. FIG. 36 shows an example table of optical data of each lens element of the optical imaging lens 8 according to the eighth example embodiment. FIG. 37 shows an example table of aspherical data of the optical imaging lens 8 according to the eighth example embodiment.

As shown in FIG. 34, the optical imaging lens 8 of the present embodiment, in an order from an object side A1 to an image side A2 along an optical axis, may comprise an aperture stop STO, a first lens element L1, a second lens element L2, a third lens element L3, a fourth lens element L4, a fifth lens element L5, a sixth lens element L6 and a seventh lens element L7.

The configuration of the concave/convex shape of surfaces, comprising the object-side surfaces L1A1, L2A1, L3A1, L5A1, L6A1 and L7A1 and the image-side surfaces L2A2, L3A2, L4A2, L5A2, L6A2 and L7A2, and positive or negative configuration of the refracting power of each lens element may be similar to those in the first embodiment;

however, the configuration of the concave/convex shape of the object-side surface L4A1 and the image-side surface L1A2 may be different from those in the first embodiment. Further, the radius of curvature and thickness of each lens element, aspherical data and related optical parameters, such as effective focal length, may be different from those in the first embodiment. Specifically, a periphery region L1A2P on the image-side surface L1A2 of the first lens element L1 may be convex, and a periphery region L4A1P on the object-side surface L4A1 of the fourth lens element L4 may be concave.

Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment may be labeled. Please refer to FIG. 36 for the optical characteristics of each lens elements in the optical imaging lens 8 of the present embodiment.

As the longitudinal spherical aberration shown in FIG. 35A, the offset of the off-axis light relative to the image point may be within about $-0.02\sim 0.03$ mm. As the curvature of field in the sagittal direction shown in FIG. 35B, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.04\sim 0.04$ mm. As the curvature of field in the tangential direction shown in FIG. 35C, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.04\sim 0.2$ mm. As shown in FIG. 35D, the variation of the distortion aberration may be within about $0\sim 2.5\%$. Compared with the first embodiment, the distortion aberration may be smaller in the present embodiment.

As shown in FIG. 36, in the optical imaging lens 8, the F_{no} is 1.706 and the image height is 6.700 mm. Referring to the aberration shown in FIGS. 35A-35D, it may be readily understood that the optical imaging lens 8 is capable to provide with enlarged aperture stop and image height, as well as good imaging quality.

Please refer to FIG. 46B for the values of each parameter and $(T4+G45)/(T5+G56)$, $(\text{ImgH}+T4+G45)/(T5+G56)$, $(T1+G23)/(T3+G34)$, $(T5+T6+BFL)/(G56+G67)$, $(G45+T5)/(T2+G34)$, $(V3+V4+V5)/V6$, $TL/(T5+T6+T7)$, $ALT/(T1+G23)$, $(T1+T4)/G45$, $TTL/(T1+G67)$, $EFL/(G12+T2+G23+T3)$, $(T2+T4)/T5$, $(T6+T7)/T3$, $(G12+T2+G23+T3)/G67$, $(T2+T3+T5)/T7$, $(G34+T4)/G23$, $\text{ImgH}/(T4+T6)$, $(G45+G56)/T4$ and $\text{ImgH}/(T1+T2)$ of the present embodiment.

Reference is now made to FIGS. 38-41. FIG. 38 illustrates an example cross-sectional view of an optical imaging lens 9 having seven lens elements of the optical imaging lens according to a ninth example embodiment. FIGS. 39A, 39B, 39C and 39D show example charts of a longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens 9 according to the ninth example embodiment. FIG. 40 shows an example table of optical data of each lens element of the optical imaging lens 9 according to the ninth example embodiment. FIG. 41 shows an example table of aspherical data of the optical imaging lens 9 according to the ninth example embodiment.

As shown in FIG. 38, the optical imaging lens 9 of the present embodiment, in an order from an object side A1 to an image side A2 along an optical axis, may comprise an aperture stop STO, a first lens element L1, a second lens element L2, a third lens element L3, a fourth lens element L4, a fifth lens element L5, a sixth lens element L6 and a seventh lens element L7.

The configuration of the concave/convex shape of surfaces, comprising the object-side surfaces L1A1, L2A1, L3A1, L5A1, L6A1 and L7A1 and the image-side surfaces

L2A2, L3A2, L5A2, L6A2 and L7A2, and positive or negative configuration of the refracting power of each lens element except for the fifth lens element L5 may be similar to those in the first embodiment; however, the configuration of the concave/convex shape of the object-side surface L4A1 and the image-side surfaces L1A2 and L4A2 may be different from those in the first embodiment. Further, the radius of curvature and thickness of each lens element, aspherical data and related optical parameters, such as effective focal length, may be different from those in the first embodiment. Specifically, a periphery region L1A2P on the image-side surface L1A2 of the first lens element L1 may be convex, an optical axis region L4A1C on the object-side surface L4A1 of the fourth lens element L4 may be concave, an optical axis region L4A2C on the image-side surface L4A2 of the fourth lens element L4 may be convex, a periphery region L4A2P on the image-side surface L4A2 of the fourth lens element L4 may be concave, and the fifth lens element L5 may have negative refracting power.

Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment may be labeled. Please refer to FIG. 40 for the optical characteristics of each lens elements in the optical imaging lens 9 of the present embodiment.

As the longitudinal spherical aberration shown in FIG. 39A, the offset of the off-axis light relative to the image point may be within about $-0.02\sim 0.025$ mm. As the curvature of field in the sagittal direction shown in FIG. 39B, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.06\sim 0.06$ mm. As the curvature of field in the tangential direction shown in FIG. 39C, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.06\sim 0.12$ mm. As shown in FIG. 39D, the variation of the distortion aberration may be within about $0\sim 4.5\%$.

As shown in FIG. 40, in the optical imaging lens 9, the Fno is 2.105 and the image height is 6.700 mm. Referring to the aberration shown in FIGS. 39A-39D, it may be readily understood that the optical imaging lens 9 is capable to provide with enlarged aperture stop and image height, as well as good imaging quality.

Please refer to FIG. 46B for the values of each parameter and $(T4+G45)/(T5+G56)$, $(\text{ImgH}+T4+G45)/(T5+G56)$, $(T1+G23)/(T3+G34)$, $(T5+T6+BFL)/(G56+G67)$, $(G45+T5)/(T2+G34)$, $(V3+V4+V5)/V6$, $TL/(T5+T6+T7)$, $ALT/(T1+G23)$, $(T1+T4)/G45$, $TTL/(T1+G67)$, $EFL/(G12+T2+G23+T3)$, $(T2+T4)/T5$, $(T6+T7)/T3$, $(G12+T2+G23+T3)/G67$, $(T2+T3+T5)/T7$, $(G34+T4)/G23$, $\text{ImgH}/(T4+T6)$, $(G45+G56)/T4$ and $\text{ImgH}/(T1+T2)$ of the present embodiment.

Reference is now made to FIGS. 42-45. FIG. 42 illustrates an example cross-sectional view of an optical imaging lens 10 having seven lens elements of the optical imaging lens according to a tenth example embodiment. FIGS. 43A, 43B, 43C and 43D show example charts of a longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens 10 according to the tenth example embodiment. FIG. 44 shows an example table of optical data of each lens element of the optical imaging lens 10 according to the tenth example embodiment. FIG. 45 shows an example table of aspherical data of the optical imaging lens 10 according to the tenth example embodiment.

As shown in FIG. 42, the optical imaging lens 10 of the present embodiment, in an order from an object side A1 to an image side A2 along an optical axis, may comprise an aperture stop STO, a first lens element L1, a second lens

element L2, a third lens element L3, a fourth lens element L4, a fifth lens element L5, a sixth lens element L6 and a seventh lens element L7.

The configuration of the concave/convex shape of surfaces, comprising the object-side surfaces L1A1, L3A1, L5A1 and L6A1 and the image-side surfaces L3A2, L5A2, L6A2 and L7A2, and positive or negative configuration of the refracting power of each lens element may be similar to those in the first embodiment except for the fourth lens element L4; however, the configuration of the concave/convex shape of object-side surfaces L2A1, L4A1, L7A1 and the image-side surfaces L1A2, L2A2 may be different from those in the first embodiment. Further, the radius of curvature and thickness of each lens element, aspherical data and related optical parameters, such as effective focal length, may be different from those in the first embodiment. Specifically, a periphery region L1A2P on the image-side surface L1A2 of the first lens element L1 may be convex, an optical axis region L2A1C on the object-side surface L2A1 of the second lens element L2 may be concave, an optical axis region L2A2C on the image-side surface L2A2 of the second lens element L2 may be convex, the fourth lens element L4 may have negative refracting power, a periphery region L4A1P on the object-side surface L4A1 of the fourth lens element L4 may be concave, and a periphery region L7A1P on the object-side surface L7A1 of the seventh lens element L7 may be concave.

Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment may be labeled. Please refer to FIG. 44 for the optical characteristics of each lens elements in the optical imaging lens 10 of the present embodiment.

As the longitudinal spherical aberration shown in FIG. 43A, the offset of the off-axis light relative to the image point may be within about $-0.025\sim 0.025$ mm. As the curvature of field in the sagittal direction shown in FIG. 43B, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.05\sim 0.05$ mm. As the curvature of field in the tangential direction shown in FIG. 43C, the focus variation with regard to the three wavelengths in the whole field may fall within about $-0.45\sim 0.1$ mm. As shown in FIG. 43D, the variation of the distortion aberration may be within about $0\sim 4\%$.

As shown in FIG. 44, in the optical imaging lens 10, the Fno is 2.102 and the image height is 6.700 mm. Referring to the aberration shown in FIGS. 43A-43D, it may be readily understood that the optical imaging lens 10 is capable to provide with enlarged aperture stop and image height, as well as good imaging quality.

Please refer to FIG. 46B for the values of each parameter and $(T4+G45)/(T5+G56)$, $(\text{ImgH}+T4+G45)/(T5+G56)$, $(T1+G23)/(T3+G34)$, $(T5+T6+BFL)/(G56+G67)$, $(G45+T5)/(T2+G34)$, $(V3+V4+V5)/V6$, $TL/(T5+T6+T7)$, $ALT/(T1+G23)$, $(T1+T4)/G45$, $TTL/(T1+G67)$, $EFL/(G12+T2+G23+T3)$, $(T2+T4)/T5$, $(T6+T7)/T3$, $(G12+T2+G23+T3)/G67$, $(T2+T3+T5)/T7$, $(G34+T4)/G23$, $\text{ImgH}/(T4+T6)$, $(G45+G56)/T4$ and $\text{ImgH}/(T1+T2)$ of the present embodiment.

Any range of which upper and lower limits, including the upper and lower limits, defined by the values disclosed in all of the embodiments herein may be implemented in the present embodiments.

According to above illustration, the longitudinal spherical aberration, field curvature in both the sagittal direction and tangential direction and distortion aberration in all embodiments may meet the user requirement of a related product in

the market. The off-axis light with regard to three different wavelengths may be focused around an image point and the offset of the off-axis light relative to the image point may be well controlled with suppression for the longitudinal spherical aberration, field curvature both in the sagittal direction and tangential direction and distortion aberration. The curves of different wavelengths may be close to each other, and this represents that the focusing for light having different wavelengths may be good to suppress chromatic dispersion. In summary, lens elements are designed and matched for achieving good imaging quality.

The contents in the embodiments of the invention include but are not limited to a focal length, a thickness of a lens element, an Abbe number, or other optical parameters. For example, in the embodiments of the invention, an optical parameter A and an optical parameter B are disclosed, wherein the ranges of the optical parameters, comparative relation between the optical parameters, and the range of a conditional expression covered by a plurality of embodiments are specifically explained as follows:

(1) The ranges of the optical parameters are, for example, $\alpha_2 \leq A \leq \alpha_1$ or $\beta_2 \leq B \leq \beta_1$, where α_1 is a maximum value of the optical parameter A among the plurality of embodiments, α_2 is a minimum value of the optical parameter A among the plurality of embodiments, β_1 is a maximum value of the optical parameter B among the plurality of embodiments, and β_2 is a minimum value of the optical parameter B among the plurality of embodiments.

(2) The comparative relation between the optical parameters is that A is greater than B or A is less than B, for example.

(3) The range of a conditional expression covered by a plurality of embodiments is in detail a combination relation or proportional relation obtained by a possible operation of a plurality of optical parameters in each same embodiment. The relation is defined as E, and E is, for example, $A+B$ or $A-B$ or A/B or $A*B$ or $(A*B)^{1/2}$, and E satisfies a conditional expression $E \leq \gamma_1$ or $E \geq \gamma_2$ or $\gamma_2 \leq E \leq \gamma_1$, where each of γ_1 and γ_2 is a value obtained by an operation of the optical parameter A and the optical parameter B in a same embodiment, γ_1 is a maximum value among the plurality of the embodiments, and γ_2 is a minimum value among the plurality of the embodiments.

The ranges of the aforementioned optical parameters, the aforementioned comparative relations between the optical parameters, and a maximum value, a minimum value, and the numerical range between the maximum value and the minimum value of the aforementioned conditional expressions are all implementable and all belong to the scope disclosed by the invention. The aforementioned description is for exemplary explanation, but the invention is not limited thereto.

The embodiments of the invention are all implementable. In addition, a combination of partial features in a same embodiment can be selected, and the combination of partial features can achieve the unexpected result of the invention with respect to the prior art. The combination of partial features includes but is not limited to the surface shape of a lens element, a refracting power, a conditional expression or the like, or a combination thereof. The description of the embodiments is for explaining the specific embodiments of the principles of the invention, but the invention is not limited thereto. Specifically, the embodiments and the drawings are for exemplifying, but the invention is not limited thereto.

Additionally, the section headings herein are provided for consistency with the suggestions under 37 C.F.R. 1.77 or otherwise to provide organizational cues. These headings

shall not limit or characterize the invention(s) set out in any claims that may issue from this disclosure. Specifically, a description of a technology in the "Background" is not to be construed as an admission that technology is prior art to any invention(s) in this disclosure. Furthermore, any reference in this disclosure to "invention" in the singular should not be used to argue that there is only a single point of novelty in this disclosure. Multiple inventions may be set forth according to the limitations of the multiple claims issuing from this disclosure, and such claims accordingly define the invention(s), and their equivalents, that are protected thereby. In all instances, the scope of such claims shall be considered on their own merits in light of this disclosure, but should not be constrained by the headings herein.

What is claimed is:

1. An optical imaging lens, comprising a first lens element, a second lens element, a third lens element, a fourth lens element, a fifth lens element, a sixth lens element and a seventh lens element sequentially from an object side to an image side along an optical axis, each of the first, second, third, fourth, fifth, sixth and seventh lens elements having an object-side surface facing toward the object side and allowing imaging rays to pass through and an image-side surface facing toward the image side and allowing the imaging rays to pass through, wherein:

the second lens element has negative refracting power; the third lens element has negative refracting power, and an optical axis region of the object-side surface of the third lens element is concave;

an optical axis region of the object-side surface of the fifth lens element is concave, and a periphery region of the image-side surface of the fifth lens element is convex; the sixth lens element has negative refracting power, and an optical axis region of the image-side surface of the sixth lens element is concave;

lens elements of the optical imaging lens are only the seven lens elements; and

a thickness of the fourth lens element along the optical axis is represented by T4, a distance from the image-side surface of the fourth lens element to the object-side surface of the fifth lens element along the optical axis is represented by G45, a thickness of the fifth lens element along the optical axis is represented by T5, a distance from the image-side surface of the fifth lens element to the object-side surface of the sixth lens element along the optical axis is represented by G56, and the optical imaging lens satisfies the inequality:

$$(T4+G45)/(T5+G56) \geq 1.500.$$

2. The optical imaging lens according to claim 1, a thickness of the first lens element along the optical axis is represented by T1, a distance from the image-side surface of the second lens element to the object-side surface of the third lens element along the optical axis is represented by G23, a thickness of the third lens element along the optical axis is represented by T3, a distance from the image-side surface of the third lens element to the object-side surface of the fourth lens element along the optical axis is represented by G34, and T1, G23, T3 and G34 satisfy the inequality:

$$(T1+G23)/(T3+G34) \geq 3.000.$$

3. The optical imaging lens according to claim 1, a thickness of the sixth lens element along the optical axis is represented by T6, a distance from the image-side surface of the seventh lens element to an image plane along the optical axis is represented by BFL, a distance from the image-side surface of the sixth lens element to the object-side surface of

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the seventh lens element along the optical axis is represented by G67, and T5, T6, BFL, G56 and G67 satisfy the inequality:

$$(T5+T6+BFL)/(G56+G67)\leq 3.000.$$

4. The optical imaging lens according to claim 1, wherein a thickness of the second lens element along the optical axis is represented by T2, a distance from the image-side surface of the third lens element to the object-side surface of the fourth lens element along the optical axis is represented by G34, and G45, T5, T2 and G34 satisfy the inequality:

$$(G45+T5)/(T2+G34)\geq 3.900.$$

5. The optical imaging lens according to claim 1, wherein an Abbe number of the third lens element is represented by V3, an Abbe number of the fourth lens element is represented by V4, an Abbe number of the fifth lens element is represented by V5, an Abbe number of the sixth lens element is represented by V6, and V3, V4, V5 and V6 satisfy the inequality:

$$(V3+V4+V5)/V6\geq 4.500.$$

6. The optical imaging lens according to claim 1, wherein a distance from the object-side surface of the first lens element to the image-side surface of the seventh lens element along the optical axis is represented by TL, a thickness of the sixth lens element along the optical axis is represented by T6, a thickness of the seventh lens element along the optical axis is represented by T7, and EFL, G67 and T7 satisfy the inequality:

$$TL/(T5+T6+T7)\leq 4.500.$$

7. The optical imaging lens according to claim 1, wherein a sum of the thicknesses of all seven lens elements along the optical axis is represented by ALT, thickness of the first lens element along the optical axis is represented by T1, a distance from the image-side surface of the second lens element to the object-side surface of the third lens element along the optical axis is represented by G23, and ALT, T1 and G23 satisfy the inequality:

$$ALT/(T1+G23)\leq 3.500.$$

8. An optical imaging lens, comprising a first lens element, a second lens element, a third lens element, a fourth lens element, a fifth lens element, a sixth lens element and a seventh lens element sequentially from an object side to an image side along an optical axis, each of the first, second, third, fourth, fifth, sixth and seventh lens elements having an object-side surface facing toward the object side and allowing imaging rays to pass through and an image-side surface facing toward the image side and allowing the imaging rays to pass through, wherein:

an optical axis region of the image-side surface of the first lens element is concave;

the second lens element has negative refracting power;

the third lens element has negative refracting power, and an optical axis region of the object-side surface of the third lens element is concave;

an optical axis region of the object-side surface of the fifth lens element is concave, and a periphery region of the image-side surface of the fifth lens element is convex;

the sixth lens element has negative refracting power;

an optical axis region of the image-side surface of the seventh lens element is concave;

lens elements of the optical imaging lens are only the seven lens elements; and

an image height of the optical imaging lens is represented by ImgH, a thickness of the fourth lens element along

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the optical axis is represented by T4, a distance from the image-side surface of the fourth lens element to the object-side surface of the fifth lens element along the optical axis is represented by G45, a thickness of the fifth lens element along the optical axis is represented by T5, a distance from the image-side surface of the fifth lens element to the object-side surface of the sixth lens element along the optical axis is represented by G56, and the optical imaging lens satisfies:

$$(ImgH+T4+G45)/(T5+G56)\geq 7.400.$$

9. The optical imaging lens according to claim 8, a thickness of the sixth lens element along the optical axis is represented by T6, and ImgH, T4 and T6 satisfy the inequality:

$$ImgH/(T4+T6)\geq 3.900.$$

10. The optical imaging lens according to claim 8, wherein a thickness of the first lens element along the optical axis is represented by T1, a thickness of the second lens element along the optical axis is represented by T2, and ImgH, T1 and T2 satisfy the inequality:

$$ImgH/(T1+T2)\geq 3.900.$$

11. The optical imaging lens according to claim 8, wherein a thickness of the first lens element along the optical axis is represented by T1, and T1, T4 and G45 satisfy the inequality:

$$(T1+T4)/G45\leq 2.200.$$

12. The optical imaging lens according to claim 8, wherein a distance from the object-side surface of the first lens element to an image plane along the optical axis is represented by TTL, a thickness of the first lens element along the optical axis is represented by T1, a distance from the image-side surface of the sixth lens element to the object-side surface of the seventh lens element along the optical axis is represented by G67, and TTL, T1 and G67 satisfy the inequality:

$$TTL/(T1+G67)\leq 4.600.$$

13. The optical imaging lens according to claim 8, wherein an effective focal length of the optical imaging lens is represented by EFL, a distance from the image-side surface of the first lens element to the object-side surface of the second lens element along the optical axis is represented by G12, a thickness of the second lens element along the optical axis is represented by T2, a distance from the image-side surface of the second lens element to the object-side surface of the third lens element along the optical axis is represented by G23, a thickness of the third lens element along the optical axis is represented by T3, and EFL, G12, T2, G23 and T3 satisfy the inequality:

$$EFL/(G12+T2+G23+T3)\leq 5.000.$$

14. The optical imaging lens according to claim 8, wherein thickness of the second lens element along the optical axis is represented by T2, and T2, T4 and T5 satisfy the inequality:

$$(T2+T4)/T5\leq 2.000.$$

15. An optical imaging lens, comprising a first lens element, a second lens element, a third lens element, a fourth lens element, a fifth lens element, a sixth lens element and a seventh lens element sequentially from an object side to an image side along an optical axis, each of the first, second, third, fourth, fifth, sixth and seventh lens elements having an object-side surface facing toward the object side and allow-

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ing imaging rays to pass through and an image-side surface facing toward the image side and allowing the imaging rays to pass through, wherein:

an optical axis region of the image-side surface of the first lens element is concave;

the second lens element has negative refracting power;

the third lens element has negative refracting power, and an optical axis region of the object-side surface of the third lens element is concave;

an optical axis region of the object-side surface of the fifth lens element is concave;

the sixth lens element has negative refracting power, and a periphery region of the image-side surface of the sixth lens element is convex;

an optical axis region of the image-side surface of the seventh lens element is concave;

lens elements of the optical imaging lens are only the seven lens elements; and

an image height of the optical imaging lens is represented by $ImgH$, a thickness of the fourth lens element along the optical axis is represented by $T4$, a distance from the image-side surface of the fourth lens element to the object-side surface of the fifth lens element along the optical axis is represented by $G45$, a thickness of the fifth lens element along the optical axis is represented by $T5$, a distance from the image-side surface of the fifth lens element to the object-side surface of the sixth lens element along the optical axis is represented by $G56$, and the optical imaging lens satisfies:

$$(ImgH+T4+G45)/(T5+G56) \geq 7.400.$$

16. The optical imaging lens according to claim 15, wherein a thickness of the sixth lens element along the optical axis is represented by $T6$, a thickness of the seventh lens element along the optical axis is represented by $T7$, a thickness of the third lens element along the optical axis is represented by $T3$, and $T6$, $T7$ and $T3$ satisfy the inequality:

$$(T6+T7)/T3 \leq 4.000.$$

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17. The optical imaging lens according to claim 15, wherein a distance from the image-side surface of the first lens element to the object-side surface of the second lens element along the optical axis is represented by $G12$, a thickness of the second lens element along the optical axis is represented by $T2$, a distance from the image-side surface of the second lens element to the object-side surface of the third lens element along the optical axis is represented by $G23$, a thickness of the third lens element along the optical axis is represented by $T3$, a distance from the image-side surface of the sixth lens element to the object-side surface of the seventh lens element along the optical axis is represented by $G67$, and $G12$, $T2$, $G23$, $T3$ and $G67$ satisfy the inequality:

$$(G12+T2+G23+T3)/G67 \leq 2.300.$$

18. The optical imaging lens according to claim 15, wherein a thickness of the second lens element along the optical axis is represented by $T2$, a thickness of the third lens element along the optical axis is represented by $T3$, a thickness of the seventh lens element along the optical axis is represented by $T7$, and $T2$, $T3$ and $T7$ satisfy the inequality:

$$(T2+T3+T7)/T7 \leq 3.200.$$

19. The optical imaging lens according to claim 15, wherein a distance from the image-side surface of the third lens element to the object-side surface of the fourth lens element along the optical axis is represented by $G34$, a distance from the image-side surface of the second lens element to the object-side surface of the third lens element along the optical axis is represented by $G23$, and $G34$, $T4$ and $G23$ satisfy the inequality:

$$(G34+T4)/G23 \leq 2.000.$$

20. The optical imaging lens according to claim 15, wherein $G45$, $G56$ and $T4$ satisfy the inequality:

$$(G45+G56)/T4 \geq 1.000.$$

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